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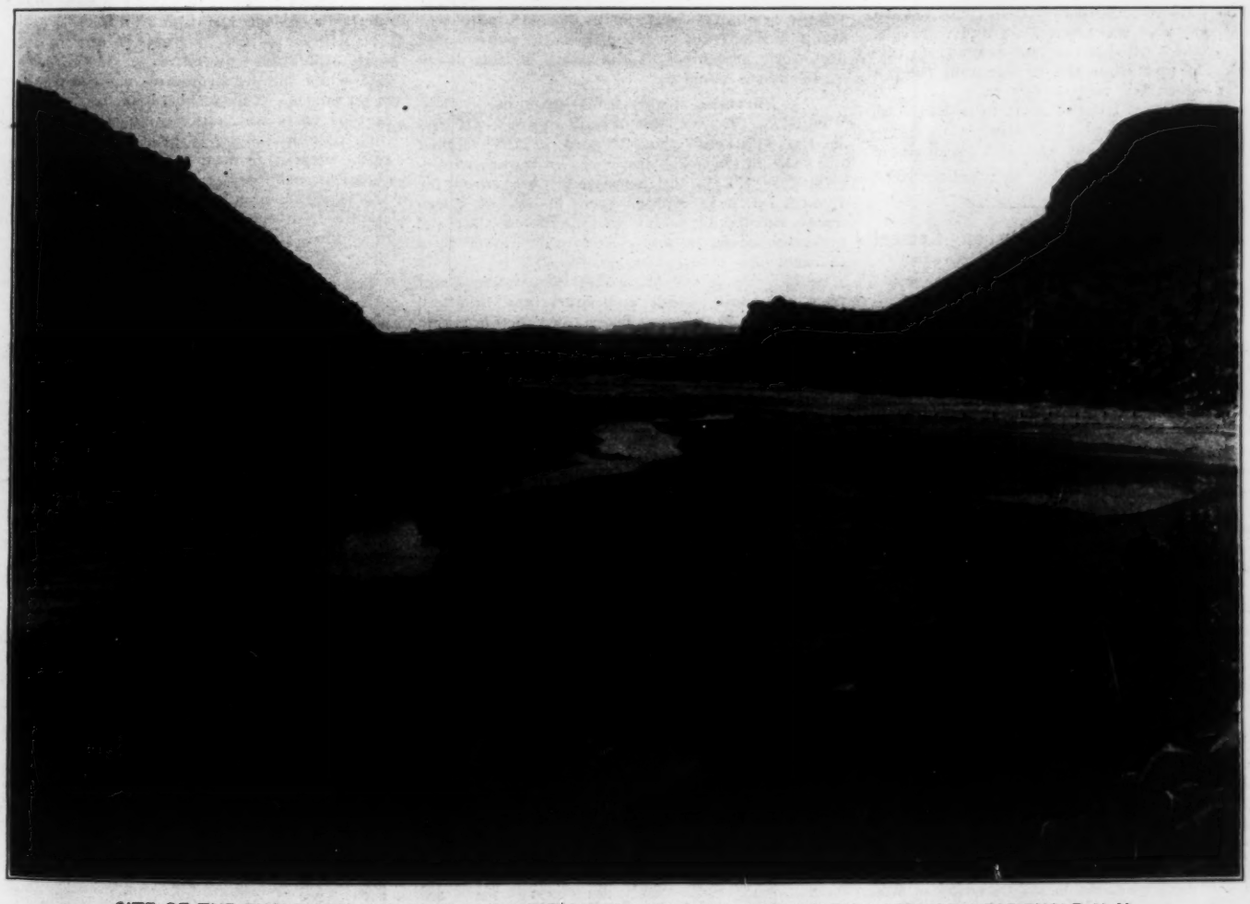
The Engle Dam and Reservoir, Rio Grande Project, U. S. Reclamation Service.

The Engle Dam and Reservoir, the chief features of the Rio Grande project of the U. S. Reclamation Service, are to be proceeded with as rapidly as possible. The storage dam across the Rio Grande, near Engle, N. M., will be of rubble concrete, with a gravity section, and will have a maximum height of 265 ft., a gross length of 1,400 ft., and will contain 410,000 cu. yds. of masonry. The spillway will be at an elevation of 190 ft. above the bed of the river. The reservoir thus formed will have an area of 40,000 acres and a capacity of 2,538,000 acre-feet (about 110 billion cu. ft., or 800 billion gals.) and will be "the largest in the world" in point of capacity, according to a statement made by Mr. F. H. Newell, M. Am. Soc. C. E., Director of the Reclamation Service. A view of the site of the dam is shown herewith.

The Rio Grande has a drainage area of 37,000 sq. miles above the dam, with an average elevation of 8,000 ft. above sea level. The average annual rainfall on the drainage basin is 15 ins. The irrigable area included in this project is 180,000 acres, lying at an average elevation of 3,700 ft. above sea level, with an annual average rainfall of 9½ ins., and a temperature range of 0° F. to 100° F. The soil consists of sandy loam and fertile alluvium. The duty of water on this land is placed at 2½ acre-feet per acre per year at the farm (supply of water, 2½ ft. deep). The principal products of this land, it is expected, will be alfalfa, corn, melons, and other fruits and vegetables. The irrigable area is located in Sierra, Socorro, and Dona Ana Cos., N. M., and El Paso Co., Texas.

This project has been under consideration for over seven years, reconnaissance having begun March 1, 1903, and the dam having been authorized by Congress and $1,000,000 appropriated for



SITE OF THE ENGLE DAM, RIO GRANDE IRRIGATION PROJECT, U. S. RECLAMATION SERVICE, NEAR ENGLE, N. M.

(Looking up-stream. The view is taken diagonally to the center line of the dam, which runs from the hill on left to the high, rocky point on the right, just back of the low ridge.)

it on Feb. 5, 1905. The project was not actually authorized by the Secretary of the Interior until Dec. 2, 1905. On June 12, 1906, the terms of the Reclamation Act were extended to Texas. On Nov. 20, 1906, construction was begun on what is known as the Leasburg unit. This unit consists of a diversion dam, which has since been completed at a cost of $210,000, and an irrigation canal which now supplies the water to about 15,000 acres. In addition to the amount already expended, it is estimated that $8,790,000 will be required for the purchase of lands within the reservoir site for grading and building a railroad to the dam, for the construction of the Engle Dam itself, and also for the construction of three other diversion dams not yet designed, and for the main distribution system in the Mesilla Valley below El Paso. It may be added that the Leasburg diversion dam is a rubble concrete weir, of 9 ft. maximum height, with a masonry length of 600 ft. and an earth-fill length of 1,600 ft.

Delays in connection with the Rio Grande project have been due in part to the necessity of entering into a satisfactory treaty with Mexico regarding its claim to water from the Rio Grande. In fact, claims presented by Mexico alleging that proposed diversions from the river would affect water rights held by Mexican citizens caused the U. S. Attorney-General, so far back as May, 1897, to begin proceedings to prevent the construction of irrigation works by the Rio Grande Dam & Irrigation Co. at Elephant-Butte on the Rio Grande, about 100 miles above El Paso, at or near the site of the proposed Engle Dam. It was largely due to the outcome of these complications that the Reclamation Service finally entered upon this project. A treaty signed with Mexico on May 21, 1906, provided that the United States shall deliver to Mexico a total of 60,000 acre-feet annually in the bed of the Rio Grande River at the headworks of the old Mexican Canal above the City of Juarez, Mex. On account of this treaty provision, the United States has appropriated $1,000,000 outside the reclamation fund toward the construction of the Engle Dam and reservoir. Altogether, the United States has spent from this appropriation and from the reclamation fund a total of over half a million dollars.

A branch railway from a point near Engle on the main line of the Santa Fe Railway to the site of the dam is being built and will be operated under a contract with the railway company named.

The Effect of Alkali Water on Cement Mortars.*

By A. J. FISK, Jr.,† Assoc. M. Am. Soc. C. E.

The destructive effect of alkali water on concrete and cement mortars has been forcibly brought to the attention of the engineering profession on many projects throughout the West. Concrete culverts have failed and substructures have been weakened where the concrete was in contact with water or soil containing alkali. This series of tests was conducted to secure definite evidence of this destructive effect.

By numerous observations of the action of alkali water on concrete it was noted that the greatest action took place at or near the water surface. Grooves were actually eaten out of the sides of concrete culverts and parapet walls along the water line, while concrete which was constantly below water was, apparently, not damaged at all. It was, therefore, suggested that the air must be one agent in the breaking down of the concrete. With this in mind, the following theories were the basis for these tests:

That the previous mortars absorb the alkali water which, on drying out, leave the soluble salts in the concrete.

That during the drying out, the alkaline salts crystallize and expand.

That after repeated wetting and drying, the expansion due to crystallization is so great that it breaks down the minute particles of the cement.

That the greatest destructive action is mechanical.

MATERIALS AND METHODS.—The cements used were a standard Portland and a standard natural, both passing the standard specifications for cement as prescribed by the American Society for Testing Materials. Standard sand was used in all mixes.

The alkali water used came from one of the small creeks tributary to Sun River, Montana. It contained 8,988 parts of dissolved solids per million—practically a 1% solution. As only five gallons of alkali water were available for these tests, not enough could be spared for a complete analysis. However, a good analysis of alkali from the same belt is given below, and it is probable the water used contained the same salts in practically the same proportion.

COMPOSITION OF ALKALI NEAR GREAT FALLS, MONTANA.
(From bulletin of Montana Agricultural College.)

.11%	Silica
4.84%	Calcium Sulphate
23.83%	Magnesium Sulphate
.54%	Potassium Sulphate
59.67%	Sodium Sulphate
7.86%	Sodium Chloride
3.13%	Sodium Carbonate
99.98%	Total

All briquettes were made and tested according to the standard specifications prescribed by the American Society for Testing Materials. No one or seven-day tests were made except in the preliminary tests of the cements.

The cement laboratory was kept within a few degrees of 70° F. during the entire period covered by the tests.

In all, 288 briquettes were tested. The tensile strength (average of four briquettes) and treatment are shown in the accompanying table.

It will be noted that for each set of tests, one-half of the briquettes were mixed with pure water and one-half with alkali water.

All briquettes were broken at the expiration of the total time indicated in the schedule. Where briquettes were cured in both pure and alkali water, they were placed in pure water first. All briquettes of the same mixture were made on the same day.

Portland Cement Briquettes.

Test No. 1 gave the tensile strength of the several mixtures when treated in the regular way, the briquettes being cured in pure water.

In Test No. 2, the briquettes were cured for 7 days in pure water, then placed in alkali water for 21 days. It will be noted that the breaking strengths are considerable higher than those of Test No. 1.

In Test No. 3, the briquettes were taken direct from the moist closet and submerged in alkali water for 28 days. Their average breaking strengths were somewhat higher than those of Test No. 2.

As the briquettes in Tests 1, 2 and 3 were treated exactly alike, with the exception of the curing, it is evident that the curing in alkali water accelerates the set, increasing the strength. The alkali water used was rich in sulphates. It is believed that the acceleration of set was due to these sulphates. To support this deduction, the following quotation is given from R. K. Mead's book entitled "Portland Cement": "With plaster paris, (Ca SO_4) H_2 O, it was found that addition up to 2% retarded set, and that above 2%, set was rapidly increased. . . . This is due to the fact that plaster paris has quick setting properties." This acceleration of set was also noted by Prof. Blazier when experimenting with sea water. D. K. Butler, in his book on "Portland Cement," quotes Prof. Blazier and says: "Briquettes placed in sea water for 28 days broke 50-60 lbs. higher than those placed under fresh water."

Tests 4 and 5 show results similar to those of Tests 1, 2 and 3.

In Test No. 6, the briquettes which had cured in pure water for 28 days were placed alternately in air and alkali water for 28 days, two days in air to one day in water. It is thought that this treatment was similar to the physical conditions which concrete encounters in an alkali belt. The treatment may have been a little more severe than any which would occur naturally in the same length of time. It is noted that the briquettes were wet nine times in the alkali water and dried out afterwards. It is also that Test No. 1 shows their strength before being treated alternately with air and alkali water, and Test No. 6 shows their strength after this treatment.

The briquettes of Test No. 6 were placed under the microscope immediately after breaking. Alkali crystals were found throughout the entire section even in the neat briquettes. In fact, in the neat briquettes the crystals were more uniformly distributed throughout the cross section than in the leaner mixtures. In the lean mixtures the crystals were more in groups in the voids.

In the dense briquettes the small per cent of voids was soon filled with alkaline salts and repeated crystallization during drying out reduced the strength about 60%. In the 1:3 briquettes considerable crystallization could take place before the voids were filled. Had the 1:3 briquettes been treated for a longer time they, doubtless, would have continued to become weaker. The regular gradation in the weakening from the dense neat briquettes to the 1:3 mixture would seem to support the expansion theory.

Natural Cement Briquettes.

No acceleration of set was noted when briquettes were cured in alkali water.

It will be noted, by Tests 1 and 6, that the neat briquettes showed a weakening of about 25% while the 1:2 briquettes showed an increase in strength. The writer believes that the per cent of voids was so great in the 1:2 briquettes that they had not yet been filled with alkaline salts when the briquettes were broken. If a chemical disintegration takes place, one would expect the lean mixture to be affected first. The results from the natural cement briquettes seem to confirm the expansion theory.

Conclusions.

The use of alkali water containing 1% of soluble salts gave results almost identical with those when pure water was used.

When neat Portland cement will lose 60% of its tensile strength by being wet nine times with a 1% solution of alkali water and then allowed to dry, it is evident that the alkali hazard to concrete is a serious one. The water used was stronger than is ordinarily encountered, yet with slightly alkaline water it would merely be a matter of time until the same disastrous results would occur.

No attempt was made to find a remedy for this evil. However, it seems obvious that where water or soil containing alkali is to come in contact with concrete or cement mortar, thorough waterproofing is the only safeguard.

This set of tests is not presented as conclusive. It is believed, however, that an exhaustive study would corroborate the evidence of the disastrous *physical* action of alkali water on cement mortars.

TESTS OF CEMENT MORTAR MIXED AND CURED WITH PURE AND ALKALI WATER.
(Tensile tests in lbs. per sq. in. Each tabulation is average of four briquettes.)

	Portland cement.								Natural cement.				Treatment—	
	Mixed with pure water.				Mixed with alkali water.				Pure water.		Alkali water.		Days cured in pure water.	Days cured in alkali water.
Test.	Neat.	1 to 1.	1 to 2.	1 to 3.	Neat.	1 to 1.	1 to 2.	1 to 3.	Neat.	1 to 2.	Neat.	1 to 2.		
1	724	621	418	261	729	600	439	248	214	168	204	181	28	0
2	838	650	454	256	842	604	463	272	228	196	222	202	7	21
3	890	653	444	238	898	648	466	270	225	206	206	194	0	28
4	752	726	474	314	691	654	486	318	257	208	252	218	56	0
5	896	746	500	363	826	722	520	347	262	202	250	214	28	28
6	310	337	292	226	276	354	317	228	154	218	150	199	28	See Note 1

Note 1.—For 28 days placed alternately in air and alkali water—2 days in air to 1 day in water.

*Results of tests conducted in the University of Wisconsin Testing Laboratory, Oct., 1908, to Feb., 1909.

†Assistant Engineer, U. S. Reclamation Service, St. Ignatius, Mont.

Field and Office Methods in a Triangulation and Plane-Table Survey of the Ducktown Copper Mining District.

By BENJAMIN H. CASE,* M. Am. Inst. M. E.

In the spring of 1904, the writer, at that time resident engineer for the Tennessee Copper Co., at Ducktown, Tenn., was called upon to start a general survey of the territory embracing the various mines and smelting works of the district. The section is exceptionally well adapted to the application of a triangulation system of measurement. The timber in the immediate vicinity has been cut away for use as fuel in formerly roasting the ores, or destroyed by the deleterious action of the sulphurous fumes from the roast-beds and smelteries. Besides this, the topography of the country is such that triangulation stations that may be seen from each other, may be conveniently established on the tops of the various small knobs that occupy the region. Geologists state that the Ducktown "basin" is a peneplain, and that these knobs are the stumps of a formerly existing plateau, which has been degraded during the lapse of the ages.

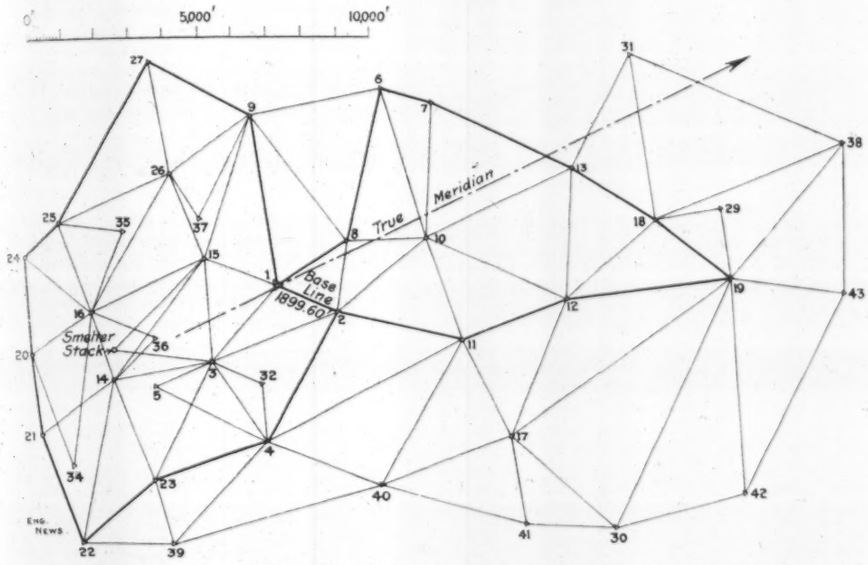


FIG. 1. TRIANGULATION DIAGRAM FOR SURVEY OF DUCKTOWN MINING DISTRICT.

Reference to the triangulation diagram will give the reader an idea of the triangulation system which was laid out in the field, as the basis for taking detail for the map. The writer will undertake, in these columns, to describe the methods used in making the survey and map.

Description of the Map and Drawing Table.

The underground mining maps of the Tennessee Copper Co. were drawn to a scale of 1 : 300, equaling 1 in. to 25 ft. It was decided that it would be most convenient to draw the general map to a scale of one-tenth that of the mine maps, or 1/3000 of field distances, equaling 1 in. to 250 ft. The area surveyed covered 2½ × 4½ miles, and the map covered an area of 56 ins. × 8 ft. on medium-weight, muslin-mounted paper. As it would have been inconvenient to work on a table with a top large enough to spread a sheet of this size upon, the writer designed, and had constructed at the company's shops, a special table with rollers, an end elevation of which, drawn from memory, is herewith shown in Fig. 2.

The drawing should be self-explanatory. It might be stated, however, that the sheet was cut about 4 ft. longer than the map's length, and marginal spaces left at both ends. One of the ends was fastened with thumb-tacks to one of the lower pair of rollers, and the other end brought up through a slot in one side of the table, over the top, and down through a slot in the other side, and fastened to the opposite roller. The auxiliary rollers near the top prevented too abrupt a turn over the curved edges of the drawing board. The map could be moved either way by turning one of the cranks, and tightened by the ratchet and pawl. The map could also be rolled onto either of the rollers, and the roller detached from the table by the hinged device shown at the bearings.

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Field Outfit and Operations.

The following items constituted the outfit used in the field:

Light mining transit, with U-shaped standards, reading to single minutes on both horizontal and vertical movements.
20-in. wye level.
30 × 24-in. plane-table.
Philadelphia rod, extending to 13 ft., and reading by vernier to .001 ft.
300-ft. light-weight steel tape graduated in 5-ft. intervals.
Specially designed stadia rod, 12 ft. long, self reading to .01 ft.
100-ft. steel tape graduated to 10ths and 100ths.
50-ft. linen-metallic tape for measuring buildings, etc.

The work was not done continuously, but with one or two parties in the field at a time, and at such times as the men could be spared from the mining or other routine engineering duties, hence it required a couple of years to complete it, but the expense was not felt as it would have been had the work been carried on as a special enterprise. The writer could supervise the same and attend to other duties besides.

Base Line Measurement.

It was a difficult matter to select a suitable site for a base line, owing to the extremely irregular surface conditions. The ground finally selected included a hollow between two eminences on which the terminal points were placed. This line is indicated on the diagram at "1"-"2"; 1,900 ft. was the distance first measured. This line was run in with transit and steel tape by plumbing the breaks for horizontal measurement. The distance was afterward checked by inclined measurements from transit to tack with the 300-ft. tape, vertical angles being read, and horizontal distances calculated. The distance fell two or three-tenths short of 1,900 ft.

The measurement of this base line that was finally accepted and used as the basis for calculating all of the triangles, was made thus: Hubs were lined in and driven along the line at intervals varying usually between 200 and 300 ft. Nails were driven in them, and allowed to project a half inch or so above their tops. The hubs were so placed that part of the 300-ft. tape could be stretched between two of them without touching the ground at any point throughout its length. The tape was weighed, and its weight per unit of length determined. A small spring-balance was attached to one end of the tape, and each measurement between nail heads was given a tension equal to that in which the stretch and sag would balance each other, as derived from figures given in Trautwine. No allowance was made for temperature, as the temperature at the time the measurements were made was about normal. This method gave accurate inclined measurements between rigid points. In order to reduce to horizontal distance, levels were carefully taken on the various nail heads with the wye level, and the vertical distance betwen each two consecutive points derived. By the method of squaring the hypotenuse and altitude and taking the square root of their difference, the bases, or horizontal distances between points were obtained. The sum of these distances gave the length of the base line which equaled 1,899.60, and is shown at "1"-"2" on Triangulation Diagram.

Triangulation.

A transitman and two flagmen were used on the triangulation work. As a rule the angles were measured without systematic order, the flagmen being sent to put in points and give sights at the same time, and in such way as to suit convenience of travel. Six measurements of each angle were made. The transit being set up over a point, the vernier was set at zero, and the telescope sighted at a point marking the other end of a triangle side; the upper limb was unclamped and a sight taken at the third point of the triangle. The reading being recorded, the vernier plate was left clamped, and the telescope turned on the lower limb to the first point of sight; then on the circle to the other point, and double the first reading taken. This process was repeated until six readings were obtained, the last reading being the sum of all. This last, divided by 6 gave the angle to be accepted for final record.

An ordinary wooden lining rod was used to sight to, sometimes with a white flag attached. The shortest side of the system was 1,393.77, and the longest 7,708.34 ft. These are shown on the diagram at "24"-"25" and "19"-"30," respectively.

As the triangles were extended to suit convenience, and save time and labor in the travel of the flagmen, it was impracticable to check results in the field. When an extensive network of triangles had been measured, a sketch of them was made, and the angular measurement for each noted on the sketch. To be absolutely correct, the sum of the angles of each triangle should have equaled 180°, and the sum of all the angles about each point should, of course, equal 360°. However, there was not a single instance where this was the case, but in no instance was the variation more than a fraction of a minute, usually in multiples of 10 seconds. It was decided that the most practical way to adjust the system would be to inspect the sketch carefully, and give a few seconds to one angle and take from another, until the correct values for all triangles were secured, and the sum of the angles about all of the interior triangulation points received their proper value. This was therefore done with an expenditure of considerable tedious effort.

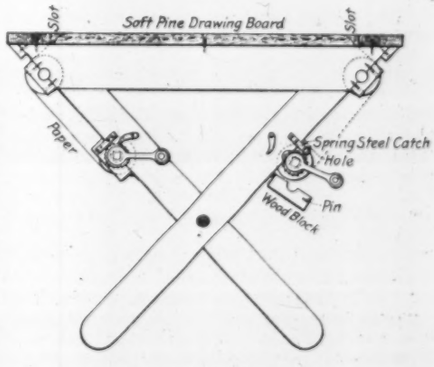


Fig. 2. Drawing Table With Moving Arrangement For Holding Large Maps.

Calculation of Triangles.

The sides of the triangles were calculated by trigonometry, the side "1"-"2," and all the angles being given for the two initial triangles adjacent to this side. The other sides being found, the calculations were extended to the other triangles of the system. Logarithmic tables of numbers from 1 to 10,000, and of angles for each 10 seconds of the quadrant were used and very little work therefore required for figuring difference and proportional parts.

The writer would state that in laying out the work in the field effort was made, at all times, to make the minimum angles not less than 30°. It was found impracticable to do this in all cases, and several angles were between 20° and 30°. Where two triangles entered into the calculation of a side common to the two, the side was calculated from both separately, and a mean of them taken as the distance for the side. All calculations were based on the measured base line, "1"-"2," but a check was made on the line "6"-"7," which was measured by similar methods to those used for "1"-"2." The difference between the measured and calculated distance was .08 ft.

Checking by Rectangular Coordinates.

In order to check the triangulation, and also to provide an accurate method for plotting the work on the map, a system of rectangular coordinates was adopted, in which the true meridian, as determined by observations on Polaris, was made the axis of ordinates, and the triangulation point, "1," the origin of coordinates. On the map, lines were drawn with red ink, parallel and at right angles to the north-south line as thus determined, forming squares with 4-in. sides, equivalent to 1,000 ft. by scale. The zero point, "1," was at the intersection of two of these lines, and all the other triangulation points were figured to be, N-E, S-E, S-W, or N-W of this point.

To check the work, two closing polygons were figured, both of which included the base line, "1"-"2," as a side common to both. One lay to the south of the base line, and the other to the north. They are both indicated on the diagram by the heavy lines.

In the south polygon, the distance traversed is about 6⅞ miles, and the total error of closure only .14 ft. = 1 in 250,000, about. In the north polygon, the distance traversed is a little over 6 miles, and the error of closure is .78 ft. = about 1 in 41,000.

Taking Elevations.

The elevation above sea-level, as obtained from the railroad bench-marks, was taken on all the triangulation points. Two closing polygons similar to those described, but not so extensive, were run with the level, and close checks secured. From stations on these polygons, the elevation of the outlying points were obtained with the transit. The transit was set up over one of the points and the height of the telescope above the point measured. A sight was then taken at the target of the level rod held on the point whose elevation was required. The difference in elevation between the two stations was derived by taking the vertical angle, and multiplying its tangent by the horizontal distance between points, and allowing for instrument and target heights.

Plane-Table Methods.

Having completed and checked the triangulation, and calculated the latitude and departure of each point, the stations were plotted on the map by scaling along the red coordinate lines previously described.

The plane-table was used to locate buildings, railroads, roads, mines, smelters and other features required for the map. In order to expedite the work of transferring the data thus secured from the plane-table sheets to the general map, a thin, tough paper was used for the sheets, on which the triangulation points were traced from the map to be used in orienting the table in the field. When the field work on one of the sheets was completed, the sheet was placed over the map so that the triangulation points of the sheet coincided with those corresponding on the map, and with a hard pencil the outline was made by indentation through the sheet. Afterward the outline was penciled and inked on the map.

As the triangulation stations were too far apart to permit of taking all detail from them, intermediate or substations were established with the plane-table, sometimes by intersection from two convenient main stations, at others by traversing with the tape. For locating the various fixed objects for the map, a stadia rod, held vertically by using a rod-level, was used. A stadia slide-rule in the hands of the plane-table man allowed horizontal distances to be quickly reduced by reading intercepted distances between stadia wires on the vertical rod, and the angle of depression or elevation on the vertical circle of the alidade.

Two corners of a building would be taken by sights of this kind and the sides measured by the rodman and an assistant. If the rodman was too far away to call the measurements intelligibly to the plane-table man, he made sketches and handed them in at first opportunity, the plane-table man having marked the points on the sheet as they were taken.

A flat wooden scale was first used for plotting distances on the sheet, but as this was frequently blown from the table by the wind, a 12-in. triangular steel scale was substituted for it. Each of the six faces was graduated into decimals of a foot: from 1/100 to 1/600. The 1/300 scale was used, each division representing 10 ft. In this connection the writer would suggest that it should be the practice among engineers to use this scaling system on map work, as it gives the map distances in decimal ratios to field distances and makes it simple to convert them into the metric scale. On the title corner of the map there was drawn both a scale to feet and one to meters.

Taking Contours.

It was the writer's intention to have contours taken for the map in 20-ft. intervals, and a small section of the surface was contoured with the plane-table. However, pressure of other work prevented its completion, and an arrangement was made by the Tennessee Copper Co. with the United States Geological Survey to do the contouring. The map was therefore sent to Washington, and photographed to one-eighth its scale, the same as that of the Triangulation Diagram. With these photographic copies, on which the triangulation points were plotted, the contours were taken with plane-tables by Messrs. Oscar Jones and R. W. Berry, Topographers for the U. S. G. S.

The plan was to sketch the topography on the general map by copying from the small map of the Geological Survey. It was then to be traced on the plane-table sheets and the contours adjusted to the larger scale in the field with the plane-table. This was not done, however, as the writer left the employ of the company shortly after the government work was done.

A small section of the ground had been contoured, under the writer's direction, as previously stated, and the method which was accurate and fairly rapid, was as follows:

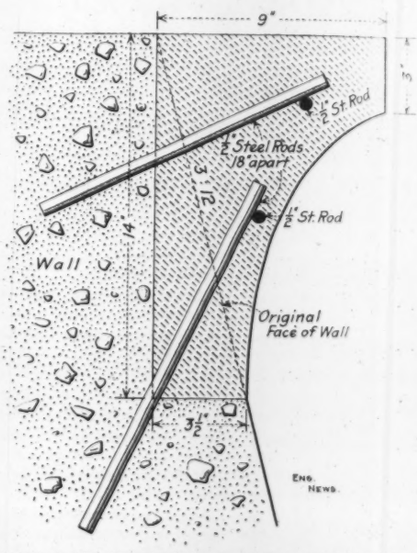
The plane-table was set up over a triangulation point or substation, and in the vicinity the wye-level was set up and the height of instrument determined from a bench-mark. There were required three men for this work, one at plane-table, one at level, and a rodman. The stadia rod always held vertical, was used on this work. Knowing his instrument height the levelman figured the difference between that and the elevation of the contour required next below. The rodman would move his rod up or down the hill-side by direction of the levelman until the contour height was found, and the plane-table man would take a reading with the stadia wires; then by reading his vertical angle, and by using the stadia slide-rule, derive his horizontal distance and plot the point on the sheet, while the levelman and rodman were finding another contour point on the ground. The levelman would peg up or down for the various contours, while the plane-table man could take his readings within a radius of a thousand feet if not obstructed by the ground. It would have required too much time for the plane-table man to find his own points, as it would be a case of "cut and try."

Permanently Marking the Triangulation Points.

During the progress of the work, wooden stubs were driven to mark the location of the triangulation points. These were afterward replaced by pieces of 2½-in. pipe set about 3 ft. in the ground, and secured by pouring cement grout around them. The pipe was threaded at one end and a cast-iron cap having a hole drilled through its center was screwed on. The number of the station was marked on the cap by making indentations with a center-punch. The hole marked the position where the tack had been, and the top of the cap was set at the same elevation as that previously occupied by the top of the hub.

A Wave-Break Added to a Concrete Sea Wall.

At the U. S. Naval Station at Key West, Fla., there is a concrete sea wall which originally sloped back from the vertical on a batter of 3 ins. to the foot, with its top only about 4 ft. above mean tide. During any storm when the wind drove the waves above the average considerable unpleasantness and no little damage was caused by the water being driven over the



Detail of Coping Added as a Wave Break to Sea Wall at Key West Naval Station.

top of the wall and washing away the earth fill behind. To remedy this the wave-break shown in the accompanying figure was built and has effectually prevented recurrence of the above described conditions.

As will be noted, the break consists merely of a coping of concrete built on to the cut-in face of the old wall and held thereto by dowel rods and strengthened by longitudinal rods as reinforcement. The cost to the government for the addition was about 50 cts. per lin. ft.

Mr. De Witt C. Webb, M. Am. Soc. C. E., Civil Engineer, U. S. N., designed this coping, and was in charge of the engineering work at the Naval Station during its construction.

A NEW GALVANIZING METHOD, adapted for fine work, has been developed by Mr. Sherard Cowper-Coles, the well-known metallurgist, of London. It is announced that this process consists of electro plating ("cold galvanizing") and then subjecting the articles to a heat treatment that alloys the iron and zinc. It is claimed that wire cloth, as fine as 90 mesh, can be coated without filling and that fine-thread screws can be galvanized and used without need of retapping the threads.

Experiments on Small Weirs and Measuring Modules.

By J. C. STEVENS,* Assoc. Mem. Am. Soc. C. E.

An accurate knowledge of the disposition of all waters received into an irrigation system is indispensable from the standpoint of successful and conservative operation. To accomplish this at a reasonable cost presents some rather perplexing problems. On a large system there may be several thousand points where it is necessary to determine discharge. In such cases simplicity in construction of measuring devices is very important, and a just balance between the accuracy attainable and the cost of the work must always be struck. Some information relating to measuring devices of this kind was obtained recently, and will be set forth in the following:†

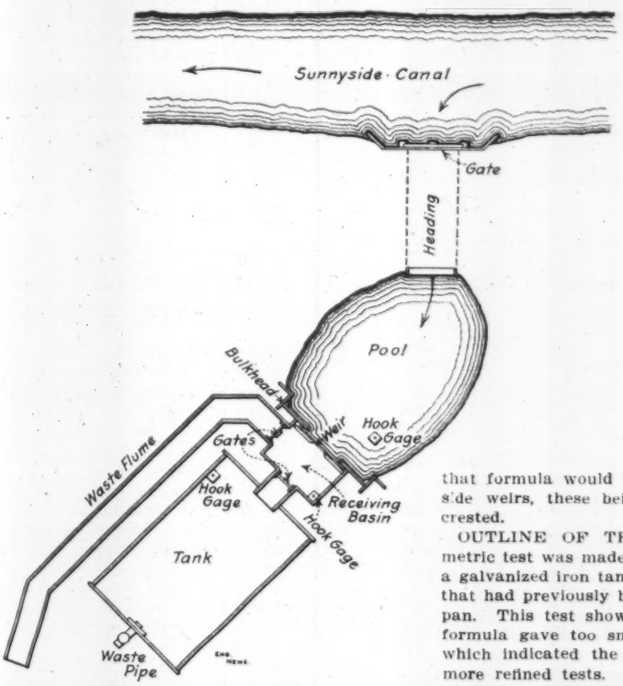


FIG. 1. PLAN OF PLANT FOR WEIR EXPERIMENTS ON SUNNYSIDE PROJECT.

During the irrigating seasons of 1908 and 1909 the writer had supervision of the hydrographic work on the Sunnyside Project of the U. S. Reclamation Service in Washington. This work was done on a cooperative basis (the actual cost thereof being refunded by the Reclamation Service to the U. S. Geological Survey). It led to some experiments on small weirs and measuring modules, with reference to their accuracy and their suitability for everyday gaging work in irrigation canals.

THE SUNNYSIDE "GALVANIZED" WEIR.—The hydrographic work on the Sunnyside Project involved among other features the calibration of the type of weir in use on that project. The weir is trapezoidal with side taper of 1 in 4, but is not quite sharp crested. It is made of 2-in. plank cut to shape and beveled to a 45° slope on the downstream side. The ends and crest are then protected with a covering of No. 24 galvanized iron. This covering is made intact by bending and soldering the iron plate before it is put on the weir board. When in place it covers the ends and crest for three or four inches downward and outward from the edges of the weir notch, including all the beveled portion of the plank. The weirs are made in 6-in., 2-ft. and 3-ft. sizes, and larger when occasion demands. All weirs measured were found to be within one or two thousandths of a foot of their nominal lengths. They are used for measuring the water at the heads of all laterals and branches and at all deliveries from them. About 5,000 were in use on the entire project in 1908.

The need for an accurate calibration of this form of weir arose as follows: Special studies were made in 1908 of the seepage from certain laterals selected for that purpose. These investigations were made on a continuous flow plan, that is, a record of the disposition of all waters received at the intake of these laterals was kept during the season. Weirs were installed at the intake and at all delivery points along the lateral also at several points in the main lateral. Each lateral was thus divided into sections and the seepage in each section determined. A local observer was employed and the heads on all weirs were read morning and evening of each day. To compute the seepage from these readings required that the discharge for any head be known with considerable accuracy.

In all previous computations the Cippoletti weir formula had been used for these weirs. This formula was devised by Cippoletti from the experiments of J. B. Francis on sharp-crested weirs 4 ft. or more in length. It was doubtful whether that formula would be applicable to the Sunnyside weirs, these being smaller and not sharp-crested.

OUTLINE OF TESTS.—A preliminary volumetric test was made on a 1-ft. weir by means of a galvanized iron tank 3 ft. square and 2 ft. deep that had previously been used for an evaporation pan. This test showed that the Cippoletti weir formula gave too small results for this weir, which indicated the advisability of undertaking more refined tests. Accordingly a wooden tank was constructed 15 ft. long, 10 ft. wide and 5 ft. deep inside. This tank was built in place at a convenient heading on the main canal where water could be handled entirely under gravity flow and was fitted up to form a complete testing arrangement, as shown in Fig. 1, by constructing a stilling pool, a waste flume, a bulkhead to hold different weirs, and admission and waste gates.

By placing flashboards in the gate grooves of the small receiving basin between weir and measuring tank, the weir under test could be submerged any desired amount.

The necessity for the latter provision arose because in the irrigation system many of the weirs in use are submerged, due either to insufficient fall in the lateral or to growth of weeds and silting as the season advances. Where distributing laterals are built in a very flat country it is frequently out of the question to install free weirs at all. Experiments were made to determine the practicability of using submerged weirs in such cases.

Fig. 3. Hook-gage in Stilling Box.

For the same reason, a measuring module was designed and tested. This involved the principle of a submerged orifice under a very low head. Tests were made by placing such modules in tandem with calibrated weirs.

Besides calibration tests, some experiments were made on the influence on the bottom and end contractions of the proximity of the sides and bottom of the leading channel to the edges of the weir.

A 1-ft. sharp-crested trapezoidal weir was also calibrated for comparison with the galvanized weir (as the Sunnyside type has been called). This sharp-crested weir was sheared from a steel plate ⅛-in. thick and the edges planed. It was the intention to continue the tests to include other sizes of sharp-crested weirs, but the experiments were interrupted for a time on account of other duties. Before they could be resumed a break occurred in the canal near the testing plant which flooded the tank, washed out the bulkhead and did so much other damage that to continue meant a reconstruction of the plant. Since the main purpose for which the plant was built had been served, and funds were limited, no attempt has been made to continue the experiments.

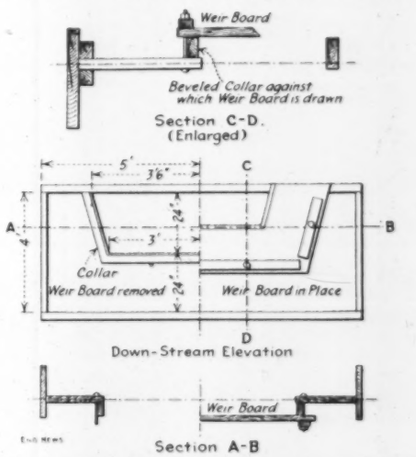


Fig. 2. Sketch Showing Method of Fixing Detachable Weir Boards to Bulkhead.

Every test made opened up new lines of investigation and it is likely that some very practical results could be secured and some very interesting data on weirs and other measuring devices gathered if the work could have been continued.

THE WEIR TESTING PLANT.—A brief description of the plant used for the weir tests is necessary in order to furnish an idea of the accuracy of the results.

The tank used was constructed of 1½-in dressed tongue-and-grooved lumber. All joints were dressed to fit as closely as possible and after completion hot tar was applied to them with a brush. The bottom was first laid on joists, then the sides were nailed to vertical posts fastened to the ends of the floor joists. The joists and vertical posts were stiff enough to prevent appreciable bulging. Opposite vertical posts were joined across the top of the tank with 1 by 6-in. boards. The water was released from the tank through a short 6-in. pipe, of which one end was screwed into the end of the tank at the bottom and supported by a collar, while to the other end was screwed a 6-in. pipe valve.

The tank was calibrated by measuring the inside length and width directly over and half way between each vertical post, with water in the tank at different levels. So little variation was found that the average of all measurements were used, that is the tank was considered a rectangular prism. These averages were 10.07

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†By permission of Mr. F. H. Newell, Director U. S. Reclamation Service.

ft. and 15.06 ft., giving as area of cross section 151.65 sq. ft., from which must be deducted for hook gage, stilling box, corner braces, etc., 0.50 sq. ft., leaving a net area of 151.15 sq. ft.

During the tests the weather was very warm and the tar would run from the joints that were above water if left exposed to the sun. They were calked with oakum and new tar applied as soon as detected. Finally the tank was shaded with canvas and no more trouble was experienced on this account. In spite of all these precautions there was a small amount of leakage,* measured as 0.0005 cu. ft. per sec. at depth of 3½ ft., but this was so small that no corrections were necessary.

The weirs to be tested were made on detachable frames. These frames were made to fit against a beveled collar on the downstream side of the bulkhead. Bolts were passed through this collar and into slots at the edges of the weir frame as shown in Fig. 2. By means of these bolts the frames could be drawn watertight against the collar, and were easily changed after loosening the bolts.

The hook-gages used were made in the field. An iron rod bent to a hook and sharpened was fastened to a wooden strip sliding in a groove on a 2 × 6-in. dressed plank. The upper end of this strip was carefully marked to hundredths of a foot. Alongside the graduated portion was a fixed strip of the same thickness carrying a vernier. The sliding strip was held at any desired position by a thumb screw which pressed a small block against it opposite the vernier. The plank to which the slide was fastened formed one side of the stilling box. This box was provided with a bottom and perforated with ½-in. auger holes to admit water freely. Fig. 3 shows one of these gages in use.

In order to determine accurately the height of the crest of each weir, a 4 × 4-in. post was driven into the bed of the leading channel with its top well below the crest of the weir. The head of a lag-screw was then cut off, the shaft flattened on opposite sides for turning with a wrench, and the top sharpened to a point. By means of a level (taken from an 18-in. wye level) fastened to a steel straightedge this point was raised to the same elevation as the crest of the weir. A detachable stilling box was placed around the point. Water being admitted very slowly into the pool, the rising water was followed with the hook-gage and as soon as the "pimple" showed over the lag-screw point the hook-gage was clamped and the reading recorded. As a check the water was then shut off and the pool drained by a siphon until the "pimple" showed again. If there was a difference the mean of the two readings was taken.

The elevation of the crest was checked frequently during the tests with each weir. It was found that although the weir frames were floated in the canal before installation the wood continued to swell and slightly raised the crest.

METHODS OF EXPERIMENTS.—The process of making a "run" was as follows:

Water was diverted from the canal into the pool and allowed to run to waste until the head had become stable. A little experimenting soon enabled one to divert approximately the desired amount, and the handle to the diverting gate was marked for the different discharges obtained. The water in the canal was under very close regulation and caused but slight variation in the head over the weirs. After the flow had become stable the hook-gage in the tank was recorded. At a signal the gates in the receiving basin were reversed and water flowed into the tank. A stop-watch was used to measure the time from closing the waste gate to the time of closing the tank gate. It was found that for discharges less than about 1.5 sec.-ft. the water could be turned directly into the tank from the beginning. The hook-gage in the tank, being provided with a stilling box, could be read with sufficient accuracy while the tank was filling. This process was almost necessary for submerged weirs in order to keep the tail water at the same level. For the higher discharges the waste valve in the tank was opened while the heads were adjusting.

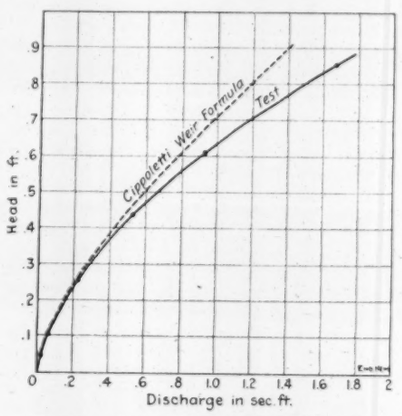


Fig. 4. Discharge Curve for 6-in. Weir.

*This was almost entirely due to small leaks where the sides joined the bottom. A tighter tank could probably have been made of straight undressed lumber without tongue and groove. The rough boards hold the tar much better than dressed lumber and the joints can in this manner be made absolutely tight.

TABLE I.—SAMPLE NOTES AND COMPUTATIONS; SUNNYSIDE WEIR CALIBRATION.

August 8, 1908.

Time of day h. m. s.	Time p. m., Seconds, (T)	Time Summation.	Head on weir.	Gage in tank.	Volume discharged, cu. ft. In time, (T).	Volume discharged, cu. ft. Summation.	Discharge for time summations, sec. ft.	Error of summations, per cent.
Series 7, No. 6. 1-ft. weir, Sunnyside type.								
2 36 52	..	..	.304	1.263	.....	.....	.....	.....
37 0	..	..	.305	.....	.....	.....	.....	.....
38 25	93	93	....	1.674	62.12	62.12	.667	+11.7
39 30	..	..	.305	.....	.....	.....	.....	.....
39 51	86	179	....	1.993	48.21	100.33	.615	+ 3.0
40 40	..	..	.305	.....	.....	.....	.....	.....
40 45	54	233	....	2.208	32.50	142.83	.608	+ 1.8
41 30	..	..	.306	.....	.....	.....	.....	.....
41 46	61	294	....	2.446	35.97	178.90	.608	+ 1.8
42 15	..	..	.304	.....	.....	.....	.....	.....
42 50	64	358	....	2.691	37.05	215.85	.603	+ 1.0
43 15	..	..	.305	.....	.....	.....	.....	.....
43 54	64	422	....	2.937	37.18	253.03	.600	+ 0.6
44 30	..	..	.305	.....	.....	.....	.....	.....
44 48	54	476	....	3.149	32.04	285.07	.599	+ 0.3
45 20	..	..	.306	.....	.....	.....	.....	.....
45 42	54	530	....	3.355	31.14	316.21	.597	0.0
46 15	33	563	.305	3.490	20.40	336.61	.597	0.0
Series 8, No. 3.								
5 30 53	..	..	.552	.665	.....	.....	.....	.....
31 28	35	35	....	.990	49.12	49.12	1.402	— 5.4
32 0	..	..	.553	.....	.....	.....	.....	.....
32 6	38	73	....	1.384	59.55	108.67	1.489	+ 0.4
32 45	..	..	.552	.....	.....	.....	.....	.....
32 55	49	122	....	1.857	71.49	180.16	1.476	— 0.8
33 15	..	..	.553	.....	.....	.....	.....	.....
33 30	35	157	....	2.214	53.96	234.12	1.491	+ 0.4
33 50	..	..	.552	.....	.....	.....	.....	.....
34 11	41	198	....	2.619	61.23	295.35	1.492	+ 0.5
34 30	..	..	.554	.....	.....	.....	.....	.....
34 54	43	241	....	3.029	61.97	357.32	1.483	0.0
35 25	..	..	.555	.....	.....	.....	.....	.....
35 43	49	290	....	3.505	71.95	429.27	1.481	0.0
36 18	35	325	....	3.843	51.09	480.36	1.478	— 0.2
36 30	..	..	.554	.....	.....	.....	.....	.....
36 51	33	358	....	4.178	50.63	530.99	1.481	0.0
37 11	20	378	.553	4.380	30.53	561.52	1.482	0.0

Two samples of readings are given in Table I. to show the general plan of recording the observations. The errors in short intervals of time are also compared with the entire time of the test; in these tests the gage in the tank was read while the water was running in.

VELOCITY OF APPROACH.—In the tabulation of daily discharges for 5,000 weirs in all sorts of channels it is entirely out of the question to make corrections for velocity of approach. When weirs in earth channels are first installed the channel above them is generally enlarged slightly to provide a pool. But this soon silts up and the discharges recorded are universally too low because no account is taken of velocity of approach.

In the seepage experiments made in 1908 the leading channels at all weirs were measured and velocity-of-approach corrections applied where necessary. In all, there were over 10,000 observations to analyze, and these corrections added greatly to the labor of computation with but a slight gain in accuracy.

In the experimental weir tests discharges of 3.0 sec.-ft. or more were required before the velocity head amounted to 0.001 ft. As heads were only measured to the nearest thousandths, these corrections were unnecessary except for high heads on 3-ft. weirs.

Experiments on Free Weirs.

For the sake of brevity the term "free weir" is used in distinction to a submerged weir. It indicates that during discharge the tail water is below the crest of the weir and that the nappe is aerated.

In the analysis of the results no attempt has been made to devise mathematical formulas for the discharge. Instead the results have been plotted on cross-section paper and rating tables prepared from the curves adjusted among the points.

The 6-in., 1-ft., 2-ft. and 3-ft. galvanized weirs were calibrated in this manner. A calibration of a 1-ft. sharp crested weir (steel weir) and a 1-ft. suppressed weir were also made for comparison with the galvanized weirs. The suppressed weir had a sharp crest of hard wood. End contractions were suppressed by board "abutments" through which the board forming the crest was passed. This type was designed and furnished by T. A. Noble, M. Am. Soc. C. E., of North Yakima, Wash., for experimental purposes. The experiments on types other than that for which the plant was constructed were necessarily put off until the other work was finished. When this was done there was so little time left that only a few points on each curve were secured, but the results serve to show the general behavior of these types as compared with the galvanized weir.

Table II. gives the results of experiments on free weirs. Tables III. to VI. give discharge tables for the galvanized weirs, prepared from these results.

Discharge curves are shown in Figs. 4 to 7, and on each diagram the Cippoletti weir formula is also plotted for purposes of comparison. In Fig. 5, for the 1-ft. weir, are shown also the discharge curves obtained for the other types of weirs tested.

For heads of about 0.08 ft. or less on the galvanized weir, the nappe adheres to the downstream face of the weir, producing the "wetted underneath" condition. This increases the discharge somewhat, as is shown by the dotted curve in Fig. 6. In general this type of weir should not be used under heads of less than 0.1 ft. if good results are expected.

ERROR OF CIPPOLETTI FORMULA FOR SMALL WEIRS.—The discharge curves for these weirs give continually larger discharges than that indicated by the Cippoletti formula. Fig. 8 is an error diagram for the Cippoletti formula as applied to the weirs tested. It is seen that the error increases with the head but decreases with the length of the weir. These errors result from two causes:

(1) The effect of end contraction is not properly

accounted for by making the end slopes of the weir ¼ to 1 as was devised by Cippoletti from the Francis formula for end contractions. The end contraction is probably a curvilinear function of the head. For very long weirs it is negligible, but in short ones a large proportion of the discharge occurs within the influence of the end contractions, hence the total error be-

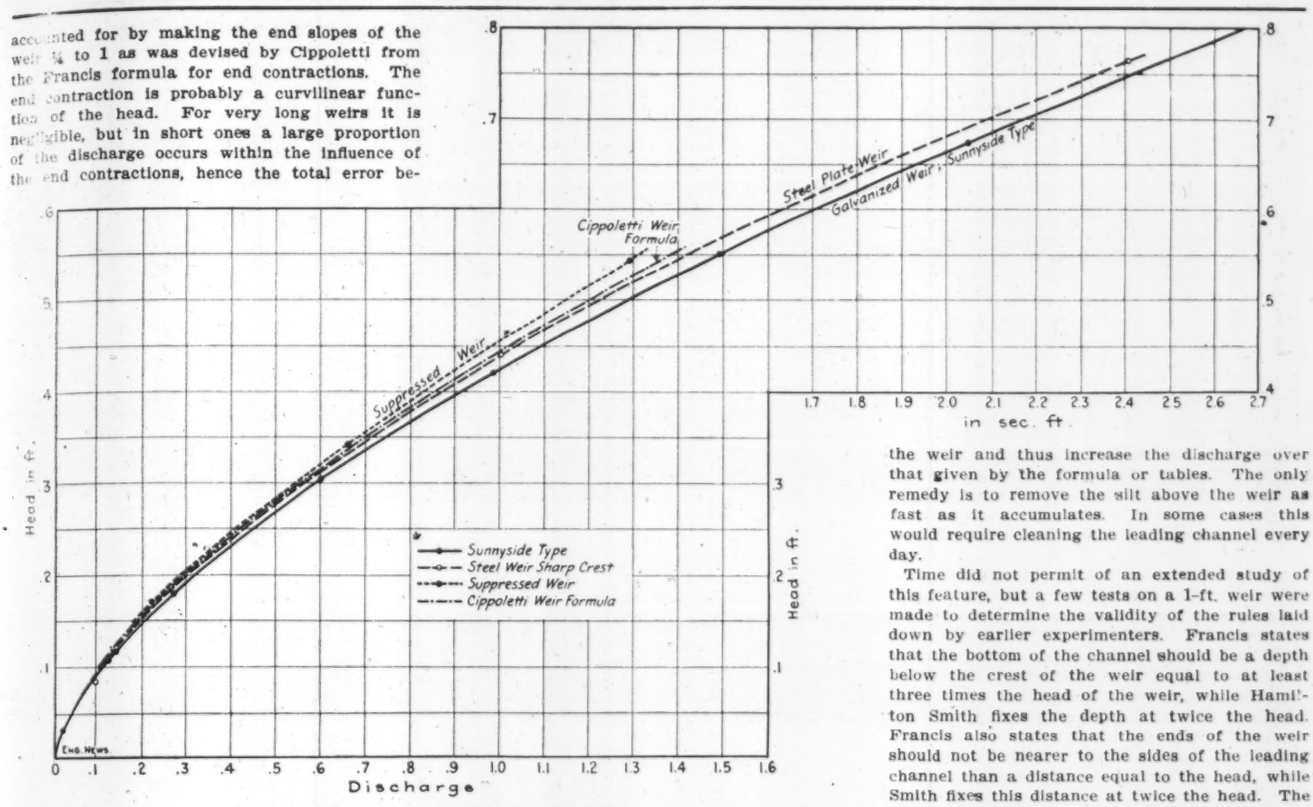


FIG. 5. DISCHARGE CURVES FOR 1-FT. WEIRS.

comes larger the shorter the weir. Since even the sharp-crested weir gives higher discharges, it would appear that the end slopes should be less than ¼ to 1 to properly account for the end contractions.

(2) The slightly rounded crest of the galvanized weir reduces the bottom contraction over that obtained with a sharp-crested weir. The radius of curvature of the crest was but little more than the thickness of the galvanized iron (.02-in.); yet it appears to have been sufficient to materially increase the discharge.

On the Sunnyside Project the continuous-rate method of delivery has been followed. The contract with each water user calls for so many second-feet of water per acre irrigated. This quantity was figured by the Cippoletti formula for the weir at each delivery measured in inches of head. Each water-user, therefore, knows how many "inches of water" he is entitled to on his weir. In the interest of economy it is necessary to hold each water-user down to his contract allowance, but to do this now would mean a reduction in the head if correctly measured on the galvanized weir. It was recognized that any attempt to reduce the head allowance would instantly meet with vigorous protest, and that the reason therefor could never be explained to the layman. But by substituting the steel weir a great saving in water could be accomplished without giving cause for protest. Each water-user would then receive more nearly the amount he was entitled to, under the same head as formerly, but not the excess to which he had become accustomed. On the new work of the project these steel weirs are being installed and also on the old headings where reconstruction is necessary. Since nearly all the water is finally measured over small weirs it is estimated that 5% more land can be brought under cultivation with the same quantity of water if the steel weir is used throughout in place of the galvanized weir. This amounts to about 2,500 acres additional, on a project where cultivated land is valued at from $400 to $2,000 per acre.

Under present arrangements each water-user uses an amount considerably in excess of his contract allowance. This represents not only a waste of water that could be used to advantage elsewhere, but frequently results in actual injury to the irrigator's own crops and damage to neighboring lands. This condition is fully recognized, but betterment can only be accomplished gradually. The natural human tendency is to take all the water possible, whereas it is a fact that in general better crops would be raised if less water was used; and in many cases less water even than the contract allowance would give far better results than are obtained under present practices.

Tests for Perfect Contraction.

The water in the Sunnyside Canal carries considerable silt, and there is a general tendency for all weirs, measuring devices and headgates to "silt up." Its effect on a weir is to destroy the perfect contractions at the sides and bottom of the weir and thus increase the discharge over that given by the formula or tables. The only remedy is to remove the silt above the weir as fast as it accumulates. In some cases this would require cleaning the leading channel every day.

Time did not permit of an extended study of this feature, but a few tests on a 1-ft. weir were made to determine the validity of the rules laid down by earlier experimenters. Francis states that the bottom of the channel should be a depth below the crest of the weir equal to at least three times the head of the weir, while Hamilton Smith fixes the depth at twice the head. Francis also states that the ends of the weir should not be nearer to the sides of the leading channel than a distance equal to the head, while Smith fixes this distance at twice the head. The Sunnyside experiments on this point (Table VII.) are not conclusive, but indicate that errors of 5 or 6% may occur if the crest and ends of the weir are nearer than the head to the bottom and sides of the leading channel. With long weirs the end contractions become relatively unimportant, but the bottom contraction must be perfect or the weir will deliver an excess of water.

In the first four tests the contractions were reduced by banking mud around the weir. After these had been run, an adjustable frame was made of boards 12 ins. wide placed perpendicular

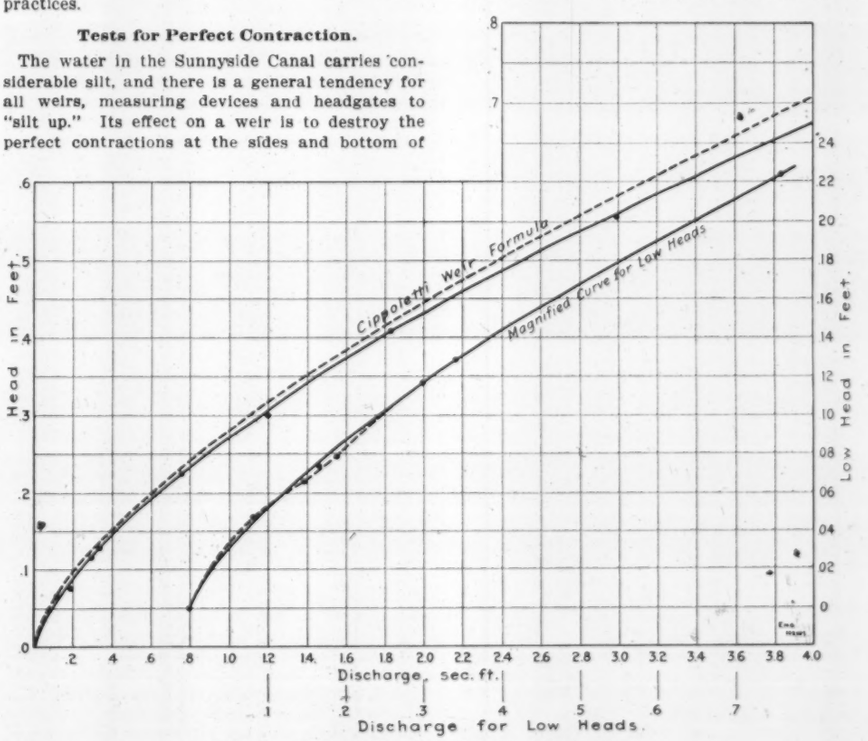


FIG. 6. DISCHARGE CURVE FOR 2-FT. WEIR.

to the plane of the weir. Better results would probably have been obtained if the boards had been 2 or 3 ft. wide, and thus projected farther into the leading channel.

Submerged Weirs.

A submerged weir is a very indifferent measuring device. The balance that exists between headwater and tailwater when the tailwater becomes relatively high is too delicate to measure accurately in the field. The labor of computing discharges and the chances for error in the field observations by the ordinary patrolman are also against its adoption.

As the irrigating season advances the laterals gradually silt up and weeds grow along the edges. On this account a large per cent of the weirs on the Sunnyside Project are submerged during September and October. The burden of keeping distributing laterals clean falls upon the water-user, but he rarely acts until the conditions are so bad that he cannot get water. During August the efficiency of the system is low. The canal and laterals are crowded to the utmost, but the quantity of water put to beneficial uses is relatively low, for the seepage losses are high and considerable damage results from water spilling from flumes and laterals.

Tests were made of the 1-ft. and 2-ft. weirs submerged. In the seepage investigations before mentioned, it was necessary to use these results considerably. In order to lessen the labor of computations a diagram was prepared from which the discharge over a submerged weir could be found much more readily than by formula. This diagram is reproduced as Fig. 9. Its use is thus explained: Let

D = the measured head on the upstream side of the submerged weir.

d = height of tailwater above crest of the weir.

Q = the discharge per foot of length for submerged weir.

H = the head on a free weir corresponding to the discharge Q.

C = the coefficient of discharge for a free weir.

TABLE II.—RESULTS OF EXPERIMENTS ON FREE WEIRS.

Series.	No.	Mean head.	Range of head.	Time. (sec.)	Volume. (cu. ft.)	Dischg. (sec. ft.)
6-in. Galvanized Weir:						
1	1	.256	.002	1,753	402.63	.23
	2	.050	0.0	2,044	42.76	.021
	3	.110	.005	1,367	89.62	.066
	4	.433	.003	875	463.14	.529
	5	.608	.002	438	408.24	.932
	6	.854	.003	348	582.49	1.647
	7	.199	.002	1,196	185.01	.155
1-ft. Galvanized Weir:						
2	1	.032	.001	9,026	161.05	.0178
	2	.098	.001	1,567	169.27	.108
	3	.211	.001	1,308	439.16	.336
	4	.384	.002	694	581.26	.838
	5	.547	.002	443	647.04	1.461
	6	.778	.001	258	661.08	2.562
4	1	.917	.002	182	614.42	3.376
	2	.673	.003	279	569.43	2.041
	3	.421	.003	509	501.06	.984
	4	.179	.001	767	209.8	.274
	5	.107	.002	749	96.74	.128
	6	.031	0.0	1,212	267.53	.022
5	3	.488	.001	447	569.99	1.275
	4	.895	.021	190	637.10	3.353
	5	.943	.003	167	599.46	3.59
8	1	.305	.002	377	227.03	.602
	2	.117	.002	596	86.20	.144
	3	.553	.003	378	561.52	1.486
2-ft. Galvanized Weir:						
9	1	.047	0.0	1,340	114.45	.083
	2	.129	.001	605	207.0	.342
	3	.078	.003	311	85.17	.187
	4	.066	.002	315	43.38	.147
	5	.073	.001	358	59.68	.167
	6	.117	.003	431	128.9	.299
	7	.224	.003	463	352.95	.759
	8	.301	.002	399	476.8	1.194
	9	.408	.001	290	545.4	1.881
	10	.557	.010	197	589.7	2.993
	11	.714	.003	125	544.3	4.354
3-ft. Galvanized Weir:						
11	1	.040	0.0	1,298	127.3	.089
	2	.132	0.0	518	267.69	.517
	3	.225	.002	451	508.8	1.128
	4	.318	.002	305	575.	1.885
	5	.425	.003	176	502.1	2.853
	6	.603	.005	112	533.6	4.743
1-ft. Steel (Sharp-crested) Weir:						
14	1	.089	.001	831	77.09	.093
	2	.442	.002	511	511.49	1.001
	3	.764	.001	210	506.8	2.41
	4	.231	.002	620	232.6	.376
1-ft. Suppressed Weir:						
15	1	.170	.004	643	144.3	.225
	2	.343	.001	435	287.5	.660
	3	.545	.002	432	584.5	1.306

TABLES III.-VI.—DISCHARGE TABLES FOR TRAPEZOIDAL WEIRS, GALVANIZED TYPE.

(As Determined from Tests on Sunnyside Project.)

TABLE III.—6-IN. WEIR.

Head, Ft..	Disch., C.F.S.	Diff., C.F.S.	Head, Ft.	Disch., C.F.S.	Diff., C.F.S.
0.01	.005	.005	0.36	.390	.017
0.02	.010	.005	0.37	.408	.018
0.03	.015	.005	0.38	.426	.018
0.04	.020	.005	0.39	.445	.019
0.05	.026	.006	0.40	.464	.019
0.06	.032	.006	0.41	.484	.020
0.07	.038	.006	0.42	.504	.020
0.08	.045	.007	0.43	.524	.020
0.09	.052	.007	0.44	.544	.020
0.10	.060	.008	0.45	.564	.020
0.11	.068	.008	0.46	.585	.021
0.12	.076	.008	0.47	.606	.021
0.13	.085	.009	0.48	.627	.021
0.14	.094	.009	0.49	.649	.022
0.15	.103	.009	0.50	.671	.022
0.16	.112	.009	0.51	.693	.022
0.17	.122	.010	0.52	.716	.023
0.18	.132	.010	0.53	.739	.023
0.19	.143	.011	0.54	.762	.023
0.20	.155	.012	0.55	.786	.024
0.21	.167	.012	0.56	.810	.024
0.22	.180	.013	0.57	.835	.025
0.23	.193	.013	0.58	.860	.025
0.24	.206	.013	0.59	.885	.025
0.25	.220	.014	0.60	.910	.025
0.26	.234	.014	0.61	.935	.025
0.27	.248	.014	0.62	.960	.025
0.28	.262	.014	0.63	.985	.025
0.29	.277	.015	0.64	1.010	.025
0.30	.292	.015	0.65	1.040	.030
0.31	.307	.015	0.66	1.070	.030
0.32	.323	.016	0.67	1.100	.030
0.33	.339	.016	0.68	1.130	.030
0.34	.356	.017	0.69	1.160	.030
0.35	.373	.017	0.70	1.190	.030

TABLE IV.—1-FT. WEIR.

Head, Ft..	Disch., C.F.S.	Diff., C.F.S.	Head, Ft	Disch., C.F.S.	Diff., C.F.S.
0.01	.006	.006	0.41	.944	.035
0.02	.013	.007	0.42	.979	.035
0.03	.021	.008	0.43	1.015	.036
0.04	.031	.010	0.44	1.052	.037
0.05	.042	.011	0.45	1.089	.037
0.06	.054	.012	0.46	1.126	.037
0.07	.067	.013	0.47	1.163	.037
0.08	.081	.014	0.48	1.200	.037
0.09	.096	.015	0.49	1.238	.038
0.10	.112	.016	0.50	1.277	.039
0.11	.130	.018	0.51	1.316	.039
0.12	.149	.019	0.52	1.359	.039
0.13	.169	.020	0.53	1.399	.040
0.14	.190	.021	0.54	1.439	.040
0.15	.211	.021	0.55	1.479	.040
0.16	.232	.021	0.56	1.520	.041
0.17	.254	.022	0.57	1.561	.041
0.18	.276	.022	0.58	1.603	.042
0.19	.299	.023	0.59	1.645	.042
0.20	.323	.024	0.60	1.688	.043
0.21	.347	.024	0.61	1.731	.043
0.22	.371	.024	0.62	1.775	.044
0.23	.396	.025	0.63	1.820	.045
0.24	.422	.025	0.64	1.866	.046
0.25	.449	.027	0.65	1.913	.047
0.26	.476	.027	0.66	1.961	.048
0.27	.504	.028	0.67	2.009	.048
0.28	.532	.028	0.68	2.058	.049
0.29	.560	.028	0.69	2.107	.049
0.30	.588	.028	0.70	2.157	.050
0.31	.617	.029	0.71	2.207	.050
0.32	.647	.030	0.72	2.258	.051
0.33	.677	.030	0.73	2.309	.051
0.34	.708	.031	0.74	2.361	.052
0.35	.740	.032	0.75	2.413	.052
0.36	.773	.033	0.76	2.466	.053
0.37	.807	.034	0.77	2.519	.053
0.38	.841	.034	0.78	2.573	.054
0.39	.875	.034	0.79	2.627	.054
0.40	.909	.034	0.80	2.682	.055

TABLE V.—2-FT. WEIR.

Head, Ft.	Disch., C.F.S.	Diff., C.F.S.	Head, Ft.	Disch., C.F.S.	Diff., C.F.S.
0.01	.013	.013	0.46	2.20	.07
0.02	.028	.015	0.47	2.27	.07
0.03	.047	.019	0.48	2.34	.07
0.04	.070	.023	0.49	2.42	.08
0.05	.095	.025	0.50	2.50	.08
0.06	.121	.026	0.51	2.58	.08
0.07	.149	.028	0.52	2.66	.08
0.08	.179	.030	0.53	2.74	.08
0.09	.210	.031	0.54	2.82	.08
0.10	.242	.032	0.55	2.90	.08
0.11	.275	.033	0.56	2.98	.08
0.12	.310	.035	0.57	3.07	.09
0.13	.347	.037	0.58	3.16	.09
0.14	.386	.039	0.59	3.25	.09
0.15	.427	.041	0.60	3.34	.09
0.16	.469	.042	0.61	3.43	.09
0.17	.512	.043	0.62	3.52	.09
0.18	.555	.043	0.63	3.61	.09
0.19	.599	.044	0.64	3.70	.09
0.20	.644	.045	0.65	3.79	.09
0.21	.690	.046	0.66	3.88	.09
0.22	.738	.048	0.67	3.97	.09
0.23	.787	.049	0.68	4.06	.09
0.24	.836	.049	0.69	4.15	.09
0.25	.888	.052	0.70	4.24	.09
0.26	.940	.052	0.71	4.33	.09
0.27	.992	.052	0.72	4.42	.09
0.28	1.045	.053	0.73	4.51	.09
0.29	1.100	.055	0.74	4.60	.09
0.30	1.16	.060	0.75	4.69	.09
0.31	1.22	.06	0.76	4.78	.09
0.32	1.28	.06	0.77	4.87	.09
0.33	1.34	.06	0.78	4.96	.09
0.34	1.40	.06	0.79	5.05	.09
0.35	1.46	.06	0.80	5.14	.09
0.36	1.52	.06	0.81	5.23	.09
0.37	1.58	.06	0.82	5.32	.09
0.38	1.64	.06	0.83	5.41	.09
0.39	1.71	.07	0.84	5.50	.09
0.40	1.78	.07	0.85	5.60	.10
0.41	1.85	.07	0.86	5.70	.10
0.42	1.92	.07	0.87	5.80	.10
0.43	1.99	.07	0.88	5.90	.10
0.44	2.06	.07	0.89	6.00	.10
0.45	2.13	.07	0.90	6.10	.10

TABLE VI.—3-FT. WEIR.

Head, Ft..	Disch., C.F.S.	Diff., C.F.S.	Head, Ft.	Disch., C.F.S.
0.01	0.01	.01	0.51	3.70
0.02	0.03	.02	0.52	3.81
0.03	0.06	.03	0.53	3.92
0.04	0.09	.03	0.54	4.03
0.05	0.13	.04	0.55	4.14
0.06	0.17	.04	0.56	4.25
0.07	0.22	.05	0.57	4.36
0.08	0.27	.05	0.58	4.47
0.09	0.32	.05	0.59	4.58
0.10	0.37	.05	0.60	4.69
0.11	0.42	.05	0.61	4.80
0.12	0.48	.06	0.62	4.92
0.13	0.54	.06	0.63	5.04
0.14	0.60	.06	0.64	5.16
0.15	0.66	.06	0.65	5.28
0.16	0.72	.06	0.66	5.40
0.17	0.78	.06	0.67	5.53
0.18	0.84	.06	0.68	5.66
0.19	0.90	.06	0.69	5.79
0.20	0.96	.06	0.70	5.92
0.21	1.03	.07	0.71	6.04
0.22	1.10	.07	0.72	6.17
0.23	1.17	.07	0.73	6.30
0.24	1.24	.07	0.74	6.43
0.25	1.32	.08	0.75	6.56
0.26	1.40	.08	0.76	6.69
0.27	1.48	.08	0.77	6.82
0.28	1.56	.08	0.78	6.96
0.29	1.64	.08	0.79	7.09
0.30	1.72	.08	0.80	7.23
0.31	1.80	.08	0.81	7.36
0.32	1.88	.08	0.82	7.50
0.33	1.96	.08	0.83	7.64
0.34	2.05	.09	0.84	7.78
0.35	2.14	.09	0.85	7.92
0.36	2.23	.09	0.86	8.06
0.37	2.32	.09	0.87	8.20
0.38	2.41	.09	0.88	8.34
0.39	2.50	.09	0.89	8.48
0.40	2.60	.09	0.90	8.62
0.41	2.70	.10	0.91	8.77
0.42	2.80	.10	0.92	8.91
0.43	2.90	.10	0.93	9.06
0.44	3.00	.10	0.94	9.20
0.45	3.10	.10	0.95	9.35
0.46	3.20	.10	0.96	9.50
0.47	3.30	.10	0.97	9.65
0.48	3.40	.10	0.98	9.80
0.49	3.50	.10	0.99	9.95
0.50	3.60	.10		

Q_1 = a tentative discharge per foot of length obtained by applying a free-flow formula or table to the head D.

$$K = \text{coefficient} = \frac{Q}{Q_1}.$$

In the field only the quantities D and d can be measured. To determine the discharge from these quantities, first enter a free flow discharge table for the particular weir under consideration and take from it a tentative discharge Q, corresponding to D. The diagram (Fig. 9) is then consulted and a coefficient K found at the intersection of lines representing the respective values of D and d as measured. This coefficient applied to the tentative discharge will give the actual discharge which occurred under a submerged condition of flow.

For example, let it be required to find the discharge over a 3-ft. weir submerged. Let the upstream head $D = 0.30$ ft., the depth of submergence, $d = 0.30$ ft. From Table VI. a tentative free flow discharge over a 3-ft. weir under head 0.80 ft. is found to be 7.23 sec. ft. From the diagram (Fig. 9) the coefficient 90% is found for values of $D = .80$ and $d = .30$. Hence the submerged discharge is $7.23 \times .90 = 6.51$ sec. ft.

After this diagram was used for the Sunnyside work, the experimental results of Francis* and those of Fteley and Stearns† were plotted on it. With very slight modification the lines were adjusted to include these experiments also. The diagram therefore represents the results on weirs of various kinds and sizes. It is likely that the lower ends of the lines are slightly curved. The points for heads below 0.2 ft. are more scattering than those for higher heads. Above 0.3 ft. head this diagram will give results within 5% of the experimental data from which it was constructed. Tables VIII. and IX.

Some study was also made of the present formulas for submerged weirs. Each formula fits the results from which it was computed, but seldom those of other experiments. None of them would fit the small weirs of the Sunnyside experiments. A study was also made of existing experimental data, on the following basis.

Assume for the moment that a constant discharge is passing over a free weir under the head H. By placing flashboards in the channel

*Lowell Hydraulic Experiments, by James B. Francis.
†Trans. Am. Soc. C. E., Vol. 12, 1883.

TABLE VII.—EXPERIMENTS FOR PERFECT CONTRACTIONS.
1-FT. WEIR.

Series.	No.	Head.	Discharge as measured.	Discharge for perfect contractions from tables.	Error, per cent.	Nearness of channel to crest of weir in terms of head. (sides)	(bottom)
7	1	.303	.604	.597	0	3.3	2.3
	2	.301	.595	.591	0	2.0	2.3
	3	.302	.598	.594	+1	1.3	2.3
	4	.300	.602	.588	+2	0.7	2.3
	5	.295	.602	.574	+5	0.0	2.3
	6	.305	.605	.602	0	2.0	1.3
	7	.305	.608	.602	+1	1.3	1.3
	8	.302	.608	.594	+2	.7	1.3
	9	.298	.606	.582	+4	0.0	1.3
	10	.307	.614	.608	+1	2.0	0.0
	11	.304	.613	.600	+2	1.3	0.0
	12	.306	.618	.605	+2	.7	0.0
5	2	.303	.624	.597	+4	3.3	.7
6	1	.137	.194	.185	+5	2.2	.7
	2	.380	.888	.841	+6	.8	.3

TABLE VIII.—FTELEY & STEARNS' AND FRANCIS' EXPERIMENTS ON SUBMERGED WEIRS.

No.	D	d	$H^{3/2}$	$D^{3/2}$	K
	Fteley & Stearns' Experiments. (Trans. Am. Soc. C. E., Vol. XII.)				
1	.3974	—.0250	.250	.250	1.00
2	.5777	.0008	.439	.439	1.00
3	.3960	.0165	.250	.249	1.00
4	.6625	.0330	.544	.539	1.01
5	.5743	.0463	.441	.435	1.01
6	.5080	.0735	.361	.362	1.00
7	.5922	.1122	.441	.453	.97
8	.4157	.1185	.250	.268	.93
9	.3251	.0956	.168	.185	.91
10	.6098	.1859	.441	.476	.93
11	.7165	.2665	.542	.606	.90
12	.5462	.2005	.361	.403	.90
13	.6328	.2614	.439	.504	.87
14	.4504	.2195	.250	.302	.83
15	.4857	.3078	.250	.339	.74
16	.3123	.5157	.342	.732	.74
17	.7425	.5186	.439	.639	.69
18	.5454	.4186	.250	.402	.62
19	.4282	.3373	.168	.280	.60
20	.7193	.5731	.360	.610	.59
21	.6246	.5894	.168	.494	.34
22	.8149	.7947	.168	.736	.23
	James B. Francis' Experiments.* (Trans. Am. Soc. C. E., Vol. XII.)				
1	.8532	.020	.786	.788	1.00
2	.8485	.065	.786	.781	1.00
3	.8522	.085	.786	.786	1.00
4	.8571	.105	.786	.793	.99
5	.8820	.220	.786	.828	.95
6	.9704	.490	.786	.955	.82
No.	D	d	(Q)	(Q_1)	K
95	1.156	.657	3.30	4.14	.80
96	1.149	.636	3.29	4.10	.80
94	1.091	.448	3.30	3.79	.87
93	1.037	.263	3.31	3.52	.94
22	1.227	.309	4.27	4.53	.94
21	1.203	.207	4.28	4.39	.98
73	2.190	1.071	9.10	10.79	.84
81	2.319	1.111	10.09	11.76	.86
43	1.720	.466	7.17	7.51	.95
69	2.034	.528	9.15	9.66	.95
68	1.994	.327	9.15	9.38	.98

*These were made on 22.2-ft. weir suppressed.

Notation:
D = Measured head on upstream side of submerged weir.
d = Depth of submergence.
Q = Discharge, determined by standard weir in tandem with submerged weir.
Q_1 = A tentative discharge for a free weir corresponding to head D.
H = Head on a free weir corresponding to discharge Q.
K = Coefficient = Q/Q_1, or $\frac{H^{3/2}}{D^{3/2}}$.

TABLE IX.—RESULTS OF EXPERIMENTS ON SUBMERGED WEIRS, SUNNYSIDE TYPE.

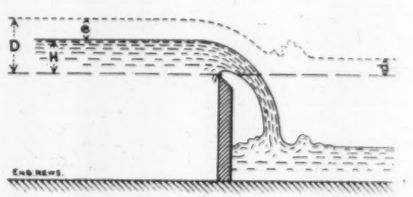
No.	D	d	(Q)	(Q_1)	K
	Series 3. 1-Ft. Weir. (Aug. 5, 1908.)				
1	.170	.005	.246	.254	.97
2	.174	.043	.248	.263	.94
3	.186	.089	.246	.290	.85
4	.192	.130	.242	.304	.80
5	.220	.175	.243	.371	.66
6	.243	.219	.242	.430	.56
7	.308	.300	.241	.611	.39
9	.133	.060	.151	.175	.86
10	.172	.146	.151	.258	.58
12	.448	.161	.985	1.082	.91
13	.471	.249	.976	1.167	.83
14	.518	.377	.966	1.348	.72
15	.640	.575	.920	1.866	.49
16	.594	.016	1.659	1.662	1.00
17	.622	.219	1.648	1.784	.91
18	.652	.347	1.636	1.923	.85
19	.712	.519	1.603	2.217	.72
20	.122	0.0	.154	.153	1.00
21	.213	.019	.312	.354	.88
22	.283	.058	.507	.540	.94
23	.613	.233	1.585	1.774	.91
24	.623	.235	1.610	1.790	.93
25	.185	.037	.266	.287	.93
26	.193	.081	.261	.306	.85
27	.315	.293	.257	.632	.39
	Series 10. 2-Ft. Weir. (Aug. 13, 1908.)				
1	.157	0.0	.435	.456	.95
2	.158	.016	.437	.460	.95
3	.175	.078	.437	.534	.82
4	.206	.155	.437	.672	.65
5	.314	0.0	1.236	1.243	.99
6	.318	.037	1.225	1.268	.96
7	.335	.118	1.234	1.365	.90
8	.367	.219	1.231	1.562	.78

Notation:
D = Measured head on upstream side of submerged weir.
d = Depth of submergence.
Q = Discharge volumetrically measured.
Q_1 = A tentative discharge for a free weir corresponding to head D, taken from tables.
K = Coefficient = Q/Q_1.

of egress or otherwise damming it the tailwater is gradually raised. No effect on the upstream head H is noticeable until the tail water reaches the level of the crest of the weir. When it rises above the crest, the weir is said to be submerged and the amount the tailwater is above the crest is the depth of submergence. This is represented by d (see sketch Fig. 12). Simultaneously with the rise of tailwater above the crest of the weir, the head on the upstream side rises also, although the discharge remains constant. Thus it can be assumed that every submerged weir was once a free weir, and has reached the submerged condition by having the channel of egress dammed in some manner. The quantities D and d are measurable, while the quantity H can for the purposes of study be taken from free-flow discharge tables for that particular weir. It will be the free-flow head corresponding to the same discharge that obtained over the weir submerged.

The usual free-flow weir formula is $Q = C\,H^{3/2}$.

The effect of submerging the weir may be expressed (see sketch below) as $e = D - H$.



Effect of Submerging a Free-flow Weir.
(Discharge assumed constant for both cases.)

It appears, therefore, that the rational formula for submerged weirs should be of the form

$$Q = C\,(D - e)^{3/2}$$

in which the coefficient C is the same as would be used on that particular weir if the discharge occurred under free overflow conditions. The quantity e should be determined experimentally and expressed in terms of D and d if possible.

A study of existing experimental data did not reveal a satisfactory relation between e and the quantities D and d, for the reason that the experiments are very few and were not made with that object in view.* It appears, however, that the effect of submergence e varies with different weirs; that is, it would be different for a truly sharp-crested weir and for a weir with the slightly rounded crest of the Sunnyside type. It would also be different for contracted weirs and for weirs with end contractions suppressed; weirs in "thin partitions" would give different results from those with broad crests, etc.

From such data as were analyzed it appears that the effect of submergence, e, is not only a function of D and d, but also of the discharge or H. When $D - d$, or the head last in passing the weir, is large, d may vary considerably without affecting D appreciably, but when $D - d$ is small, a slight change in d causes almost an equal change in D. Hence it appears that e can not be expressed in terms of D and d alone, but must include the quantity H, which is unknown, but is so related to the discharge that tentative solutions could probably be made. This fact renders such a submerged weir formula too cumbersome for general use. The diagram heretofore described fulfilled every requirement, and this line of study, although very interesting, was not followed further.

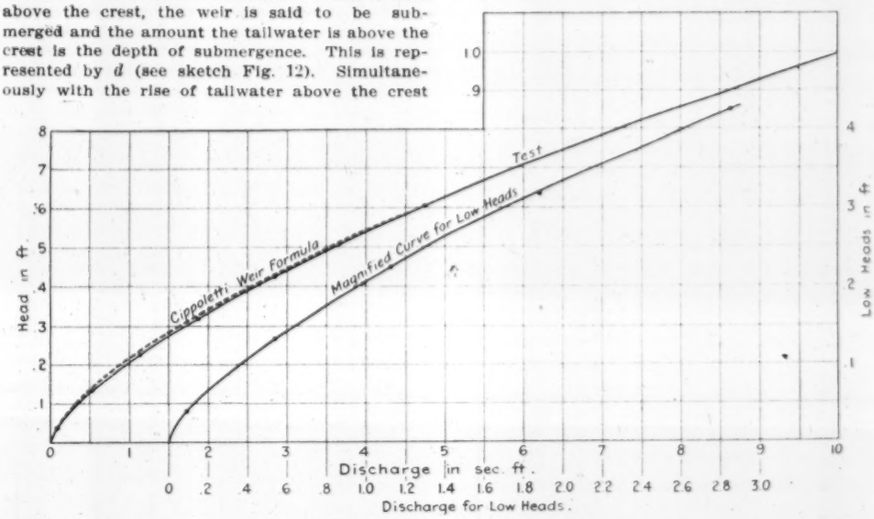


FIG. 7. DISCHARGE CURVE FOR 3-FT. WEIR.

*Bazin has a very elaborate series of experiments on submerged weirs, both thin and broad-crested, as well as irregular shaped crests. The effect of velocity of approach, however, enters prominently into his results, and corrections therefor are included in his coefficient of discharge. Without tedious recomputation of his original data the results are not comparable with those of American experimenters. The results of his experiments appear in Annales des Ponts et Chaussees, 1894 and 1896. The results for broad-crested weirs are republished in Trans. Am. Soc. C. E., Vol. 44, Dec., 1900, 364-377.

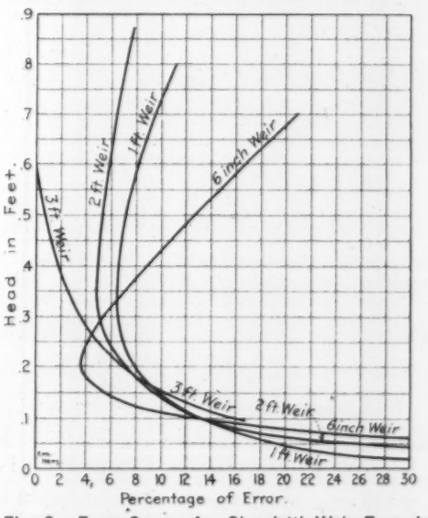


Fig. 8. Error Curves for Cippoletti Weir Formula As Applied to Sunnyside Type of Weir.

Table VIII. gives the experimental data obtained at Sunnyside plant on 1-ft. and 2-ft. weirs submerged. In Table IX. has also been added a synopsis of the experimental results of J. B. Francis and those of Fteley and Stearns on submerged weirs.

Error of Measuring Head in Plane of Weir.

It has been quite a general practice among farmers and patrolmen on the Sunnyside Project, and doubtless on other projects, to measure the head of water in the plane of the weir. This practice is, of course, unscientific and is without excuse. The errors involved are always such as to give more water than the contract allowance. Thus if a water user is entitled to 3 ins. over a weir and the head is measured over the weir blade, he would receive from 3½ to 4 ins. instead of 3 ins. The practice is entirely unnecessary and should not be allowed.

Table X. gives the results of a determination of the errors involved by measuring the head in the plane of the weir. They are seen to vary from 10 to 35%. The wide range of error is due to the impracticability of holding the rule absolutely vertical. The tests were made in the manner usually followed by patrolmen in measuring this head in the field.

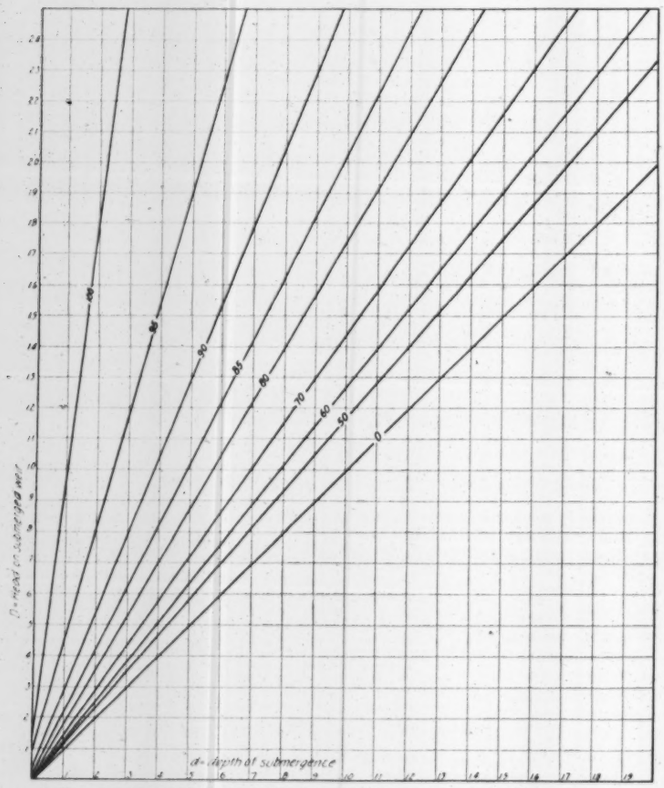

d = depth of submergence
Coefficients for submerged weirs to be applied to discharge obtained for same weir under head if not submerged

FIG. 9. COEFFICIENTS FOR SUBMERGED WEIRS.

Tests of Measuring Modules.

There is great need for a simple measuring device where the head required for weir measurements is not available. A few experiments were made on submerged orifices in the hope that this principle could be utilized.

The first experiments were made on a device suggested by O. V. P. Stout, Professor of Civil Engineering at the University of Nebraska, but the results were not entirely satisfactory. The module suggested by him was an orifice with a constant length. The height was varied by a gate, the lower edge of which formed the upper edge of the orifice. A gage was placed on each side of the orifice fixed to the wings of the frame. The zero of the upstream gage was fixed at a known distance above the zero of the downstream gage, for example, 0.1 ft. When reading the module the gate was manipulated until both gages read the same. The head in the case cited was then 0.1 ft. on the orifice and the gate opening read on a scale served by computing the discharge. Once calibrated a discharge scale could be placed alongside the scale for gate opening, whence the discharge could be recorded directly by the patrolman with a single entry in his note book and without extended computation later.

A series of tests were made on this module in the winter of 1908 at Klamath Falls, Ore., by H. D. McGlashan, Assistant Engineer, U. S. Geological Survey. The modules tested there were made with orifices 1 ft., 2 ft. and 3 ft. in length. Gate openings used were 0.5 ft. and less and heads were changed by tenths of a foot up to 0.5 ft. It was found that the head must be read with considerable accuracy if good results are to be secured, and this could not be done with the gages used. These gages were marked to 100ths of a foot, but to read to 100ths it was necessary to use stilling boxes around them. For accurate results heights should be read to thousandths. A 3-ft. sharp-crested weir was used to determine discharge and the module tested was in tandem with it. The orifice had contractions suppressed on the bottom and ends. The tests were made in a fairly wide canal, a bulkhead being built across it to accommodate the module. The results were discordant and no reason therefor could be assigned at the time.

During the summer of 1909 the writer made a few experiments on a slightly different design of module. The general principles were the same except that the gate was fixed for openings of 0.1 ft. and multiples thereof. The head was read with a differential hook gage. Fig. 10 shows a 6-in. module and Fig. 11 a 1-ft. module in use. The hook gages were placed in 2-in. pipes, one connected with the upstream side of the orifice and the other connected with the downstream side by small ¼-in. pipes as shown in Fig. 10. The hooks were small enough to stand with their points at the center of the pipes. The upstream gage carried a scale and the downstream gage the index. To facilitate reading each was provided with a thumbscrew clamp as shown. A brass plate was set flush with the inside face of the 12-in. boards forming the ends of the orifice. This plate had ¼-in. holes every tenth of a foot from the bottom of the orifice, and the gate carried a thumbbolt on each end, fastened to the downstream side, by means of which the gate opening could be fixed at any desired tenth-mark.

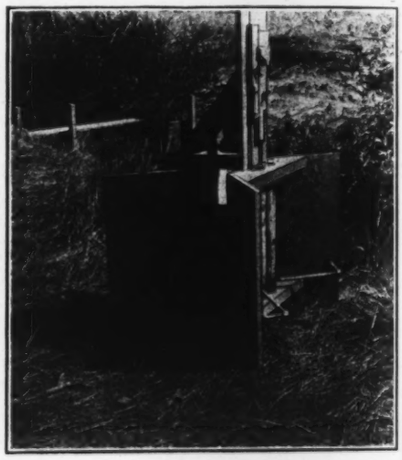


Fig. 10. Six-inch Module with Differential Hook-Gage.

Only the 1-ft. and 2-ft. sizes were tested. They were placed in tandem with a sharp-crested steel weir 3 ft. in length for the higher, and one 2-ft. in length for the lower discharges. The lateral selected was a cut-off between two others where any desired amount of water could be secured without interfering with the distribution of water for irrigation purposes.

The coefficients for these modules are continually lower than for the Stout module of the Klamath experiments, for some unknown reason. After two series had been run tests were made to determine the effect of velocity of approach on the discharge through the orifice. To do this the discharge was kept constant. The water was then raised by successive amounts so as to submerge the orifice more and more, and the depth of water on the upstream side was recorded to indicate the amount of submergence. It was found that for low heads the depth of submergence was too important a factor to be ignored. Correcting for velocity head alone does not fully account for the change in head with depth of submergence. These facts tend to so complicate the gathering and computing of discharge data that this form of module is no lon-

TABLE X.—ERROR OF MEASUREMENT HEAD IN PLANE OF WEIR.

Series.	No.	Weir.	Head from hook gage. (H)	Head measured on blade. (H')	Difference. (H—H')	Discharge—For H.	Discharge—For H'.	Error per cent.
8	2	1-ft.	.117	.09	.027	.145	.096	34
9	3	2-ft.	.078	.07	.008	.187	.145	23
9	6	2-ft.	.117	.11	.007	.299	.270	10
9	7	2-ft.	.224	.19	.034	.759	.590	22
9	8	2-ft.	.301	.252	.049	1.194	.900	15
9	9	2-ft.	.408	.34	.068	1.824	1.39	24
9	10	2-ft.	.557	.500	.057	2.993	2.51	16
9	11	2-ft.	.714	.625	.089	4.354	3.59	17
11	4	3-ft.	.318	.27	.048	1.885	1.47	21
14	1	1-ft.	.089	.073	.016	.093	.070	25
14	2	1-ft.	.442	.39	.052	1.001	.840	16
14	3	1-ft.	.764	.646	.118	2.410	1.825	25
14	4	1-ft.	.231	.2	.031	.376	.305	19
15	1	1-ft.	.170	.14	.030	.225	.165	27
15	2	1-ft.	.343	.312	.031	.660	.572	13

TABLE XI.—EXPERIMENTS FOR EFFECT OF VELOCITY OF APPROACH ON SUBMERGED ORIFICE.
(2-ft. module. Discharge constant = 2.27 sec.-ft.)

Area of orifice.	Depth above orifice.	Vel. of approach.	Head on orifice.	Vel. head.	Head on orifice cor. for Vel. App.	Theoretical discharge.
1.00	1.18	.96	.214	.014	.228	3.83
	1.25	.91	.216	.013	.229	3.84
	1.49	.76	.220	.009	.229	3.84
	1.80	.63	.224	.006	.230	3.85
	2.03	.56	.235	.005	.240	3.92
1.40	1.07	1.06	.081	.017	.098	3.51
	1.05	1.08	.074	.018	.092	3.41
	1.25	.91	.088	.013	.101	3.57
	1.50	.76	.105	.009	.114	3.79
	1.78	.64	.110	.006	.116	3.82
	2.10	.54	.119	.005	.124	3.95
2.00	1.06	1.07	.005	.018	.023	2.44
	1.30	.88	.031	.012	.043	3.33
	1.58	.72	.042	.008	.050	3.59
	1.89	.60	.047	.006	.053	3.70
	2.00	.57	.050	.005	.055	* 3.76

*Actual discharge in per cent. of theoretical.

ger a simple measuring device, and therefore loses its value.

On this account these modules are not considered of much value where accurate results are desired, although it is possible to give discharge tables for them that will fit the experimental data within 5% error. The results of tests for velocity of approach are, therefore, the only data given, and while they are negative data they are none the less valuable (Table XI.).

It is very likely that a different design could be utilized to better advantage. If an orifice was

Fig. 11. One-foot Module in Use.

made entirely in "thin plate" (1-in. lumber), the velocity and friction heads would not be so variable. This would require that the area of the orifice be small relative to the area of the channel. The device must be made to operate under low heads, 0.1 ft. or less, or it does not fulfill the purpose for which it is intended. Under higher heads the exit velocity is so high that protection must be provided or the channel will wash badly. Aside from these features it forms an obstruction in the channel that is more serious than a weir since floating trash accumulates above the orifice. It is, however, easily cleaned by raising the gate, which clears silt from the channel at the same time.

The Development of the Cincinnati Cooperative System of Engineering Instruction.*

By HERMAN SCHNEIDER,† Assoc. M. Am. Soc. C. E.

It is difficult to formulate a simple comprehensive statement of the principle underlying the cooperative system. Various attempts have been made to condense it, but perhaps the best statement of the fundamental idea is this:

The practice of engineering can not be learned in a university; it can be learned only where engineering is practiced, namely, in the shop or field. The theory underlying the practice can best be obtained by an organized system of instruction under skilled teachers.

As a matter of fact, the whole argument for the cooperative course, together with the investigation which led to it, would make a long and involved statement, and, while it might prove more conclusive than any simple expression, we have always felt that the demonstration of the scheme, together with a statement of the results achieved year by year, would be more effective. While we still believe the actual demonstration to be better than the argument, we find that many erroneous impressions prevail concerning our work.

Curiously enough, many people think that the basic idea in the cooperative system is the alternate-week arrangement. The plan by which theory and practice are combined and coordinated, is merely a detail, and the alternate-week scheme which we use is the one which happens to fit our local conditions the best. Even in our own school we are devising different systems of cooperation. For instance, after four years of experiment, we have decided to run the cooperative courses in electrical, mechanical and metallurgical engineering on the alternate-week plan for eleven months in the year, reducing the length of the usual courses from six years to five. In civil engineering, we have the alternate-week scheme eight months in the year, and for the summer months we have made an arrangement with the Union Pacific R. R. Co., whereby our students obtain field work in railroading, together with instruction given by the railroad company. In chemical engineering, there will be a marked departure, according to our present plans, from both of these details of operation.

It must be evident that for different localities, different means of getting theory and practice together will be used, and, also, in different courses, the ratio of theory to practice will vary. For example, the University of Wisconsin probably could not operate on the alternate-week plan, because of its distance from the factories of the state. It could establish a faculty in Milwaukee and have an alternate-week or fortnight scheme; but if the faculty remained in Madison, the plan would probably be to have eight months of instruction at Madison, and four months of scheduled shop work, with coordination, in Milwaukee, using four rotating sections so that the shops would always have the same quota of student apprentices. Such a plan as this would be a cooperative scheme, of course, but would have a less amount of shop work, and, in the opinion of some of our critics, would be a more beneficial arrangement than the one which we believe to be the best for our conditions in Cincinnati.

Some of the more conservative eastern institutions will hesitate to tie up as intimately with commercial shops as we have done in Cincinnati. It is probable that they will adopt some form of the cooperative system with a less amount of outside practical work, making the work less rigorous, and devising their details so as to cause the least amount of disturbance to their present systems. Four years of experience with the Cincinnati cooperative courses, however, leads me to expect failure for any cooperative scheme which is not made commercially profitable for the shops, which does not start the student at the very bottom of the practice of engineering, which eliminates the hard work that the regular mechanics do, or the regular hours they maintain or which modifies the shop discipline simply because the apprentices are university students. A course with any evasion of the disciplinary conditions which have made strong men, while it may be an advance on the old four-year system, will not meet the expectations of its sponsors.

These thoughts are born of the questions so frequently asked us by college teachers not situated in industrial centers and by others who are in factory communities but who have a vague fear that somehow the standard of their scholastic work, their dignity and their independence will be jeopardized by contact with the wicked world. It is astonishing how much opposition there is to that part of our system which requires a student to do the hard physical work of laborers and mechanics. Engineering professors, particularly, and in some cases practicing graduates from four-year courses, seem to feel strongly that the high plane upon which the engineering profession is supposed to be, is in danger of being let down a peg, if embryo engineers begin their careers as apprentices. I have never been able to get a crystallized, logical statement of these objections and personally, I believe that a goodly amount of physical work in contact with those whose lot it is to labor, should be required of every young man in his formative years, no matter what his position in life is, or is to be. Especially it should be required of future engineers. Strong men have always grown stronger and better through such contact and competition, and the weaker ones have found their levels more quickly than in any other way. Why an engineering college should not adopt Nature's rigorous methods of finding leaders is not evident, and if engineering education should be for any particular purpose, it should certainly be for the training of leaders in production and construction. In our opinion, the man who has not the will and willingness to do physical labor in the practical engineering world is not a promising candidate for the engineering school; nor do we believe that imitation work in imitation shops should be offered to the students as an equally good, but easier and more dignified, substitute for character-building, man-making, real work of real shops.

Now, I assume that we are in the business of training men for the practice of engineering; and I further take it that the practice of engineering means the economical use of the forces and resources of nature for the benefit of mankind. The day has come when we must place honest emphasis on the word "economical." We must also remember that mankind means all men, the majority of whom are those who produce and construct in using the resources of nature. We are, in fact, servants of each other, and in this mutual but complex interdependence of production, we have for some time been leading surely to a crisis, which grows more acute as the nation becomes more industrial, and which will necessitate the solution of two problems; (1) the elimination of waste in production, and (2) the scientific use of labor to the end that it may be most efficient, best rewarded, and properly conserved. These are not matters for the lawyer and politician, but for the engineer. The integration of a multitude of shop errors between the limits of Jan. 1 and Dec. 31, is now as much an engineering problem, as a deduction by calculus. The training necessary to find all the factors which enter into this integration is as much a part of engineering education as is mathematics. A working knowledge of the toxins of fatigue is as important as an ability to discover and eliminate the impurities in castings. To conserve the years of labor is as much a part of economical engineering as to find a good preservative coating for iron. A knowledge of the limitations, the weaknesses, the group subtleties of men, is as requisite as a similar knowledge of materials.

If we are to have a saving solution of this broad engineering problem of conservation in production, the men who tackle it must be initially aggressive in spirit and keen of mind; they must be deeply versed in science; they must have a thorough and intimate knowledge of men and materials; their instruction in the humanities must give them breadth of vision, and the resultant breadth of tolerance and they must know the problem as it really is. It did not take us long to learn that it was necessary to paint the shop end of the course to aspiring Edisons in broad, black, greasy, sweaty strokes. Young men came to inquire about the work and, one after another, they surrendered to their mental aversion for early hours and much grime. But there was a fine residue from this sifting—a residue that meant business. Each year our list of applicants has grown and the selection has been more and more rigid; as a result our losses during the summer tryout have decreased from 40% to 8%.

We learned the first year, and we have had it verified each year since, that the shop will spot a "yellow streak" in a man before the university even suspects it. An attempt to sneak spoiled work through is never a great success and it requires only a few days for a young man to realize that he must stand squarely on his own merits and that most of the men in overalls about him are a peculiarly keen lot of men worth cultivating. This is when a would-be Edison begins his combination course in tact and integrity.

Critics have felt that the amount of shop work given would tend to kill the scientific spirit and to instill a too practical one. In this connection it is worth mentioning that, when our faculty met with the cooperative-course students to discuss the five-year, eleven-month and the six-year, nine-month plans, all the older students desired a six-year, eleven-month plan in order that they might take up advanced scientific work, together with certain academic subjects like psychology and logic, and that they might study a more comprehensive group of technical subjects than usually included. They have become so impressed in the shop with the broader aspects of engineering, that they desire to touch not only the technical subjects of their own courses, but also many of the technical subjects of other engineering courses. As a result, courses will be arranged so that men, on graduating after five years, will be enabled to take one or two additional years if they so desire.

We, at the college end, soon found our work under a scrutiny and criticism, with final judgment suspended, and this too from a source which does not hesitate to scrutinize and criticize. We are now brought face to face with the possible failure of a university department as we never are in our four-year courses. A student, let us say, has finished successfully his work in physics; some day he does a foolish thing in the shop which indicates that he knows very little about the subject. When you confront him with the fact that he should have known better because he had been taught the theory governing it, you find his grasp on the theory to be very feeble; it is not a part of his working organism.

Experiences of this sort caused a serious introspection, on the part of our teachers, and a consequent readjustment of our courses and methods. We soon found that much of our trouble resulted from a lack of coordination between courses. After trying various plans to remedy this, we now have a system whereby each course is charted in a circle clockwise by weeks. At the periphery of the circle are the names of the teachers who tie to the particular work of any week. Every teacher gets a copy of every course chart. The instructor in charge of the course is chairman of a committee on that course, the other members being those whose work correlates with his. In this way a number of men may teach a subject which was formerly taught by one man. For example, the Professor of Metallurgy enters the Bridge Design and Testing Laboratory Courses at appropriate times; the Professor of Industrial Chemistry gives a part of the Cement Course.

Our experience also taught us that it was necessary to have a separate set of men to coordinate the work of the shop with the work of the university. A department was started to do this, and men were appointed of the grade of Assistant Professor and with the title of Coordinator. The shop coordinator is a college graduate acquainted with shop practice. He spends every morning at the university and every afternoon in the shops. His function is to make a direct weekly coordination of the work of the shop with the theory of the

*Extracts from a paper before the annual convention of the Society for the Promotion of Engineering Education, Madison, Wis., June 25, 1910.

†Dean of the College of Engineering, University of Cincinnati, and Professor of Civil Engineering, Cincinnati, Ohio.

University. One afternoon, for example, he may be at the shops of a local manufacturing company, where he will observe the student apprentices at work. He will know what they are turning out, their speeds, their feeds and cuts, the angle of the tool, how the batch of work in ticketed, how the work is set up, the power drive, everything important in connection with the operation. The next week these young men will be grouped together with their classmates for two periods in class, when he will explain the functions of the particular articles, on which the students were working, in the machine which the local manufacturing company builds. He will take up all questions of speeds, feeds, cuts, accuracy, etc. Figuratively speaking, he will take from the student apprentices the blinders which would restrict their vision except for this explanatory work. The ticketing of the batch of work is gone into, and the system of shop routine is explained. Ultimately all problems encountered—shop organization, shop accounting, cost keeping, shop planning, power transmission, heating, lighting—are discussed.

In conjunction with this, a card system is employed by means of which everything the student does in the shop that exemplifies theory taught in the university, is called in detail to the attention of the teacher of the theory, so that when the student comes to that particular theory, the exemplifications which he has had in his practical work in the shop are called to his attention. It will be seen, then, that out of the student's own experience is drawn much of his course in mechanism, thermodynamics, machine design, strength of materials, shop economics, etc.

This system has been in operation for one year, and is one of the most valuable additions we have made to the scheme. The coordinators have made a careful study of each shop, and are now completing organization charts showing the path which a student can most profitably follow through the shop. In addition to the shop chart, a chart is made for every individual student which indicates how closely this path has been followed and why there have been deviations, if any. These charts are the result of four years of closely observed experiment on the part of the university and the shops, and have been worked out by conferences between shop coordinators and shop superintendents.

A student's rating is not determined by examination, but by a record of daily efficiency. We have abolished examinations, but pay very close attention in the weekly faculty meetings to the weekly records of our cooperative students. Short written tests are given frequently, and without advance notice. A certain pace is set and if the student can not, or will not, maintain it, he is dropped from the course.

We are more and more convinced that the best thing a university can teach an engineering student is how to tackle a problem, and to this end most of our summer work is devised. All of the summer work in the university is to be constructive, following the analytical work of the previous year's theory. For example, a student's first problem will be something like this:

There is a barrel of rock salt; you are supposed to have a certain knowledge of theoretical chemistry after your year's work. Here is the laboratory; here, also are the necessary industrial implements; over there is the library. Now go and make 4 lbs. of table salt. At 5 o'clock each day let us have a written report on what you have accomplished.

Following this and other simple problems, the work becomes more complex, leading into boiler compounds and metallurgy. The student will be compelled to rely almost entirely on his own resources, except for critical suggestions following errors, and by the time he has reached his third summer it is hoped that he will be able to use the laboratory, the library and his theoretical knowledge to make a logical and effective attack on a new piece of constructive work. In his last year he will have several problems which will involve theoretical considerations that he has never met, except, perhaps, in the fundamentals of physics.

Many additional changes in curriculum and method are in process of development, looking to a more rigorous mental and physical training of our young men for work in production and construction. A few of our students will become teachers, and a few more, temperamentally fitted for work in pure science, will join those who explore beyond the ranges of the known, but the majority will continue in the more prosaic business of helping to do the world's work. And these will bring to their tasks a working knowledge of the many-sided life of shop and field, coupled with an ability to apply to it the rapidly increasing fund of knowledge which the pure scientist uncovers, to the end that the yield may be greater and the spirit of the laborer brighter. This, I take it, is engineering.

ALUMINUM PULLEYS FOR PLANERS have been found superior to those of cast-iron on account of their smaller inertia. Experiments made by the Cincinnati Planer Co. with pulleys of various materials were described briefly in the "American Machinist," July 7, 1910. Aluminum gave the best results. Compared with cast-iron, the weight reduction is about 60%; power saving, 25%; increase in strokes per hour, 15%.

Some Exposure Tests of Structural Steel Coatings.*

By CLOYD M. CHAPMAN.†

About three and a half years ago Westinghouse, Church, Kerr & Co. exposed to the weather on the roof of the building occupied by them at the southern extremity of Manhattan, 24 small steel plates each coated with a so-called "steel preservative paint." The great difference soon noted in the protective value of these paints led to the testing of other paints and coatings until some 1,600 plates have now been exposed, painted with 530 different coatings submitted by 271 manufacturers or dealers.

The results obtained to date are more or less interesting according to the conclusions which may be drawn from them. Herein we will state only the facts, the conclusions may be drawn by each for himself.

The method employed in most of these tests was as follows: Small samples of the ready mixed paints were submitted by the manufacturer or dealer, together with a statement of the principal ingredients entering into their manufacture. Each paint was applied to two mild steel plates of about No. 16 gage, 2 ins. wide and 6 ins. long, which had first been well cleaned of oil and foreign matter by rubbing with a cloth saturated with benzine. Each plate had its number plainly stamped in one corner. One plate was given one coat and the other two coats. Care was taken to give a uniform full coat to both sides and all edges of the plates. All painting was done indoors by the same person. About five days were allowed between coats for drying. After the second coat had dried the plates were fastened to boards with galvanized iron tacks and exposed on the roof at an angle of 45° facing south. Fig. 1 shows some of these plates on the boards as they are now exposed on the roof.

FIG. 1. TESTS OF STRUCTURAL STEEL COATINGS MADE BY WESTINGHOUSE, CHURCH, KERR & CO.

On the day the plates were exposed scratch marks were made with a sharp instrument across two opposite corners of each plate. These scratch marks cut through the paint film leaving bright metal exposed so that rust could and did start immediately along these lines.

At regular intervals after exposure each plate was examined and a record made of its condition. The one quality which was being sought and the prime factor which entered into the rating of the paints was protection against rust.

An arbitrary scale of ratings was adopted based on the amount of rust apparent on the plate. Until some small spot of rust appeared the plate was rated at 100%, except cases of fading, alligatoring, bad chalking, etc., without any rust apparent, which were rated at 97%. When one small spot of rust, the size of a pinhead, appeared the plate was rated at 90%. When several such spots or one larger spot of rust appeared the plate was rated at 85%. When the sum of the areas of the rust spots totaled an area of about ¼-in. square the plate was rated at 80%, when ½-in. square at 75%. When the combined area of rust spots totaled about 1 sq. in. the plate was rated at 70% and so on down the scale until zero rating indicates the plate entirely rusted on the exposed side. Fig. 2 shows a series of plates in various stages of the progress of the rust from 100% to zero. Examinations were made and results recorded at the end of two weeks, four weeks, six weeks, twelve weeks, and every three months thereafter.

The scratch marks across the corners of the plates developed some interesting results by showing the protective resistance offered by the various coatings to the spread of the rust which got its start where the bright metal was exposed. In one case the coating failed at many points and the plate rusted at each of these rusty spots, but the coating did not allow the rust to progress under it and therefore the rust spots were small and the rust at the scratch mark still confined within narrow limits. Should this paint be called a good inhibitor and a poor excluder? In another case a paint allowed the rust to spread rapidly where it once started at the scratch marks but did not allow a single spot of rust to start on any other portion of the plate. Is not this evidence of a poor inhibitor but a good excluder? Both of these plates were exposed the same length of time.

Another interesting and somewhat curious fact has been noted in these tests. It is that the various classes of pigments fall in characteristic manners. A plate coated with a graphite paint does not rust in the same manner as one coated with red lead or an iron oxide.

As the test plates were exposed from time to time throughout the year in lots of about 200 it would not be fair to compare the three or six months' rating of a paint exposed in June with the corresponding rating of one exposed in November, after the one had been subjected to warm dry weather and the other to an equal period of cold, rain and snow. For this reason, the one year and two year ratings are compared in all cases, so that all have been exposed to the four seasons in succession one or more times.

As noted above, each manufacturer was asked to state the principal ingredients in his paint and on the basis of these statements the samples were classified into groups depending upon its chief pigment, or, in the absence of pigments, upon its vehicle. In this way the paints were divided into a number of classes as follows:

CARBONS.—In this class are grouped the natural and artificial carbons except graphite.

GRAPHITES.—This class contains both the natural and artificial graphites.

IRON OXIDES.—These also include both the natural and artificial pigments, some of which were received in paste or dry form to which pure linseed oil was added in our laboratory.

RED LEADS.—This class includes both the straight red lead and oil mixed in the laboratory shortly before applying and the ready mixed red lead paints which contain considerable percentages of other pigments to keep the lead in suspension. These red leads had no other coating over them.

RED LEAD PRIMERS.—These consist of tests in which the first coat was a red lead paint, either "ready mixed" or straight red lead and oil, while the second coat was of some other class. Of course, no one coat tests could be made in this way. The second coats in this class were of widely different varieties.

WHITE LEADS.—This class is rather surprisingly small and is made up largely of paints mixed from the paste in our own laboratory.

ZINC OXIDES.—Few makers put out a zinc oxide paint for structural steel.

MINERAL HYDROCARBONS WITHOUT PIGMENTS.—This class is composed of paints made of the various kinds of tars and tarry refuse, and the various minerals

*Paper read before American Society for Testing Materials, Annual Meeting, Atlantic City, N. J., June 28-July 2, 1910.

†Engineer in Charge, Westinghouse, Church, Kerr & Co., Bridge St., New York City.

TABLE OF RESULTS OF EXPOSURE TESTS OF STRUCTURAL STEEL PAINTS MADE BY WESTINGHOUSE, CHURCH, KERR & CO.

Class.	One Year Exposure.				Two Years' Exposure.			
	One Coat		Two Coats		One Coat		Two Coats	
	No. of Tests.	Av. Rtg.	No. of Tests.	Av. Rtg.	No. of Tests.	Av. Rtg.	No. of Tests.	Av. Rtg.
Carbons	65	21%	54	70%	34	2%	36	46%
Graphites	67	18	56	66	42	3	43	45
Iron oxides	74	35	71	69	52	10	52	46
Red leads	50	58	39	77	19	16	20	61
Red lead primers	0	..	43	75	0	..	14	56
White leads	23	51	11	82	3	0	3	25
Zinc oxides	5	25	5	69	5	3	5	50
Mineral hydrocarbons without pigments	66	20	73	46	36	0	37	18
Mineral hydrocarbons with pigments.	10	16	11	53	7	0	7	20
Vegetable hydrocarbons with and without pigments	13	19	13	57	3	0	3	5
Cements	7	36	7	46	1	0	1	0
Chromates	14	32	24	70	9	0	9	39
Vehicles	22	8	7	11	3	0	3	0
Miscellaneous	94	28	103	67	70	7	85	39

of an asphaltic nature, gilsonite, elaterite, etc., but without any pigments added to them. They form one of the more numerous groups and as a rule are much lower priced than the oil paints. They also form the class for which the greatest merit is usually claimed by the makers and agents.

MINERAL HYDROCARBONS WITH PIGMENTS.—This class is made up of the same character of materials as the last, but with various pigments added. For instance, a paint made of gas tar and iron oxide would fall in this class rather than in the iron oxide class.

VEGETABLE HYDROCARBONS WITH AND WITHOUT PIGMENTS.—This class includes distillates and residual pitches of vegetable oils, etc. They are not numerous enough to divide into two groups hence those with and those without pigments are placed in the one class.

CEMENTS.—Several manufacturers have acted upon the oft published statement of the fact that Portland cement offers a protection to steel against rust and have put out a paint said to be made up largely of cement. These paints are here grouped in a class by themselves. As they have appeared in the market mostly within the past two years only one of them has had a full two years' exposure.

CHROMATES.—Another effect of recent paint literature has been to cause the appearance of a number of paints said to contain chromates or chromic acid in some form. Some of these have appeared within the past year and no tests of those can be included in this paper.

VEHICLES.—This class contains the oils, varnishes, and transparent coatings containing little or no pigment but which are more or less used for the protection of steel.

MISCELLANEOUS.—Into this class are grouped all the coatings which do not fall into one of the above groups or concerning which the maker refused proper information to enable the paint to be classified. Other subdivisions were made in our laboratory records, but they each contained so few representatives that they were all thrown into this miscellaneous class for purposes of comparison in this paper.

In the accompanying table is given a summary of the results obtained with each class of paints for one and two years exposures of one and two-coat specimens. This table also gives in each case the number of tests which entered into each result.

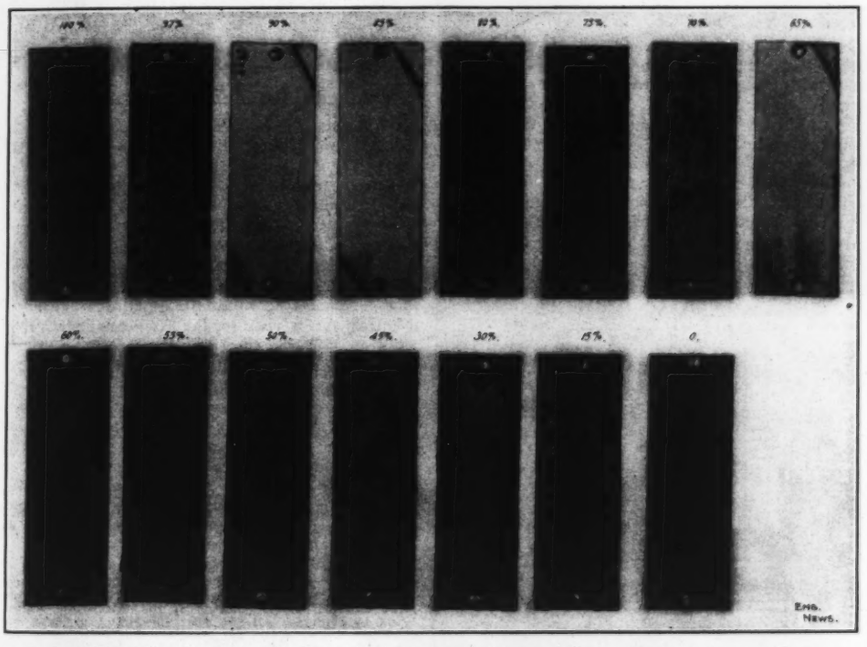


FIG. 2. PROGRESSIVE STAGES OF RUSTING AND ARBITRARY RATINGS OF EACH STAGE.

Tests of Two 5,000,000-Gal. Horizontal Pumping Engines at the Canarsie Pumping Plant, Brooklyn, N. Y.

Tests of two 5,000,000-gal. pumping engines of a triple-expansion, horizontal, fly-wheel type as installed by the Marine Engine & Machine Co., of New York, at the Canarsie Pumping Station, Borough of Brooklyn, have shown a remarkable duty, considering the moderate size of the engines and the adverse conditions under which they were operated. Full 24-hr. tests on engine No. 1 were made on June 24 and 25; those on engine No. 2 were made on June 30 and July 1. The available water-supply was so small that the engines were compelled to work with abnormally high vacuum pressure on the suction, adding to the net head, increasing this above the specified limit, and preventing complete filling of the suction chambers of the pumps. The city was unable to control the amount of superheat in the steam furnished the engines, thus making it necessary to use lower pressures than specified in order to prevent too high temperatures of steam used. The principal test data is given in the accompanying table.

CANARSIE PUMPING PLANT: SUMMARY OF RESULTS.

	As specified.	Engine No. 1.	Engine No. 2.
Date	.....	Jun 24-25	Jun 30-Jul 1
Ascertained percent slip	.....	2.064	1.274
Capacity:			
(a) On displacement corrected for plunger leakage..	.....	5,131,500	5,141,400
(b) Corrected for ascertained slip...	5,000,000	5,025,600	5,075,900
Discharge head, ft....	.....	182.14	190 53
Suction lift, ft.....	.....	23.81	23.1
Total lift, ft.....	200	205.95	213.6
Revolutions per min..	.....	46.94	47
Steam pressure, lbs...	200	175.27	179
Superheat	100°	121.1°	140.4°
Total steam condensed per 24 hrs.....	.....	57,003	57,785
Indicated horsepower..	.....	204.81	216.40
Water Hp.....	.....	261.	274.0
Lbs. Steam per I.HP..	.....	11.65	11.13
Duty corrected for ascertained slip, ft. lbs. per 1,000 lbs. steam..	150,000,000	151,474,000	156,481,000

An attempt was made during these regular tests to measure the actual slip by a pitometer-tube exploration of the main discharge. On account of the high suction head, there was too much vibration of the pitometer gage to make these determinations of value. Supplementary tests were made by Mr. F. B. Nelson, of the Department of Water Supply, Gas and Electricity, during which sufficient air was admitted to the suction chambers to eliminate the pitometer vibrations. The apparent slips shown by the pitometer readings were 6.0 and 5.4% for engines 1 and 2, respectively. These were corrected 0.136% for water diverted, 1.0% for personal errors and 2.80 and 2.90% respectively for air in the water pumped as determined by indicator cards of the water ends.

The tests were conducted by Mr. T. J. Gannon, expert for the city, Mr. J. A. Groshon, expert for the contractor, and Mr. R. P. Bolton, referee.

Other high-duty records may be recalled at this time, although it is only fair to note that the highly superheated steam employed contained some 45% more heat than saturated steam of the corresponding pressures. It is not at all accurate then to compare the duty per 1000 lbs. of steam with records based on saturated steam. The Holley, 20,000,000-gal. engine at Lardner's Point, Philadelphia, has a record of 184,476,200 ft. lbs. per 1000 lbs. steam; the Allis-Chalmers, 20,000,000-gal. engine at Bissel's Point, Milwaukee, shows 181,068,605 ft. lbs.; the Nordberg 6,000,000-gal. engine at Pittsburg was reported as showing 162,900,000 ft. lbs.; while the 3,000,000-gal. horizontal cross-compound Snow pump at Mahoney City, Pa., shows a record of 141,369,439 ft. lbs. per 1000 lbs. steam.

LABORATORY COURSES FOR HEALTH OFFICERS are offered without charge at the New York State Hygienic Laboratory, Albany, N. Y., by the State Department of Health. Beginning Aug. 1 and until further notice there will be two courses available to health officers of the state each week. One of these occupies the first four days of the week and is somewhat general in character, while the other, occupying the last four days in the week, takes up sanitary water analysis. The taking of the courses seems to be free from formalities or iron-clad rules, inasmuch as health officers are invited to attend through the complete period of either course, or to take both courses, or even to attend for a single day at a time only. Each attendant of the courses will be provided with a working table, microscope, and all necessary instruments and material. Those taking the course are requested to notify the Department of Health in advance of the proposed period of attendance.

SUBMERGED STORAGE OF COAL has been adopted by the Twin City Rapid Transit Co., of Minneapolis, Minn., as a means of storing for summer use about 12,000 tons of screenings which can be purchased cheaply in the winter season. A concrete tank about 104 × 213 ft. is subdivided into four separate and isolated bins by means of cross walls, the depth being about 14 ft. for the side walls and 11 ft. for the cross walls. The structure is built entirely of reinforced concrete. At the intersection of the cross walls is a hopper feeding a crushing plant, from which the coal falls through a shaft to a belt conveyor in a tunnel passing under the bins and running to the boiler house. Coal is dumped into the bins from railway cars, and is taken for use by a grab bucket handled by a locomotive crane. Each bin has an inlet and drain opening connecting with a pipe system laid in the conveyor tunnel. According to the "Electric Railway Journal," from which these particulars are taken, the coal can be protected from spontaneous combustion without total submersion as the water (admitted at the bottom) works its way up through the coal pile by capillary attraction. The submerged storage of coal for the navy and at the works of the Western Electric Co. has been described in Engineering News of Aug. 23, 1906, p. 203, and July 5, 1906, p. 15, respectively.

Concrete Pedestal Bridge Abutments on the New York State Barge Canal.

In the construction of the Barge Canal across New York State there have been built a number of bridges carrying roads across the line of the canal, either at the sites of old bridges across the smaller but colinear Erie Canal or else at entirely new locations. In either instance it was generally the case that the grade of the road had to be raised considerably in order to reach the bridge level with its required 15-ft. head-room, so that the abutments were built high above the original earth surface to retain the filled road afterward placed. For this particular kind of an abutment, the U-shaped type is generally used on most work but upon the Barge Canal, the Chief Bridge Designer for the State, Mr. Wm. R. Davis, devised a somewhat novel type of concrete pedestal and slab abutment, which has been built for a number of bridges across the canal.

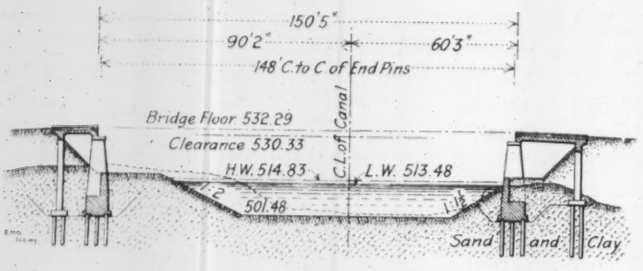


FIG. 1. GENERAL LAYOUT OF ABUTMENTS FOR TYPICAL STEEL BRIDGE ACROSS NEW YORK STATE BARGE CANAL.

FIG. 2. NEAR VIEW OF PEDESTAL ABUTMENT SHOWING SIDE SLOPE PAVING.

To suit the varying local conditions the minor details of the design are changed with each bridge, but the general design is the same as that shown in the accompanying drawings and views, which, it should be noted, do not represent the same structure.

The abutment consists of two forward pedestals, under the bridge seat, joined together with a wall high enough up to prevent the side slope from the road fill from tailing into the adjacent canal, and two rear columns. Connecting the two forward and the two back columns, respectively, are transverse beams which in turn carry the roadway slab, which connects the bridge floor proper to the earth fill approach. This whole structure is of concrete reinforced in places as shown below.

Fig. 1 shows the location of a bridge across the Barge Canal, in which these abutments were used. As will be seen, the sub-surface here is of sand and clay and so a pile footing under the pedestals and columns was required, but in many of the bridges where a more solid foundation was obtainable, these verticals were run down to rock or hard-pan without the use of the intervening piles. It will also be noticed that the level of the bridge floor is considerably above the surrounding ground and that a fill approach had to be made on both sides.

Fig. 3 shows the detail design of the north abutment of the bridge in Fig. 1. In front a wall 9 ft. 8 ins. long, in the line of the bridge and 7 ft. high extends for the whole width of the abutment, resting on a pile footing. Rising from this wall is the slender wall across the abutment to hold the toe of the fill and, on each end, the pedestals which support the bridge seat and one end of the abutment floor slab. The small retaining wall is slightly reinforced but the pedestals and the main footing wall are of plain concrete. In construction these pedestals are built first and in the top of each one is left a semi-circular or square groove, which is coated with asphalt paint and into which the forward transverse girder is molded. This asphalt painted groove forms a joint to separate the forward from the rear portions of the abutment.

The remainder of the structure is cast monolithically and is a simple combination of two pile-supported columns, cross-girders, and a heavy slab, crowned to care for the crown in the roadway. Upon this slab the ordinary road is laid.

Fig. 4 shows a bridge across the canal, in which these abutments have been used, before the earth approach has been placed. After the approach has been completed, the side slope tailing down from the fill is paved with large blocks, sometimes in two slopes as shown in the drawings, Fig. 3, and sometimes in one slope, as is well illustrated in the view in Fig. 2.

From the number of these abutments which have been built along the line of the canal, it has been found that a saving is effected over the old style U-abutment. The forms are easy to build and require only simple lumber and with any kind of skilled concrete men the expense per cu. yd. is not much greater than in a solid abutment, while at the same time it is obvious that the quantities must be much smaller in the skeleton structure. There has been one objection to some of the abutments that have been built and that is that there is more of a tendency for them to move, if on soft ground, than there is usually found in the solid abutment. It seems probable that this defect could be remedied by sufficient piling, or possibly by tying back between the two lines of columns. However, in soft ground the tendency of the lighter construction to move should be looked into thoroughly.

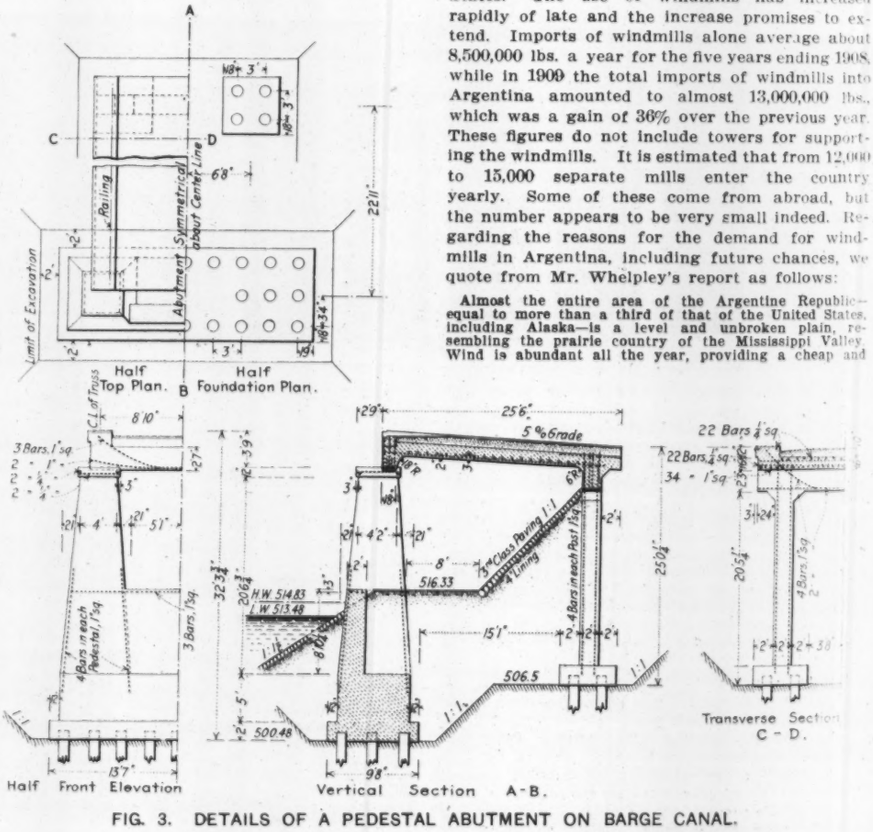


FIG. 3. DETAILS OF A PEDESTAL ABUTMENT ON BARGE CANAL.

Windmills for Pumping in Argentina.

Windmills and windmill pumping in Argentina is the subject of an interesting report from Mr. James D. Whelpley, U. S. Commercial Agent at Buenos Aires, published in Consular Reports for July 21, 1910. Mr. Whelpley states that the windmill and windmill pump market of Argentina is controlled by manufacturers of the United States. The use of windmills has increased rapidly of late and the increase promises to extend. Imports of windmills alone average about 8,500,000 lbs. a year for the five years ending 1908, while in 1909 the total imports of windmills into Argentina amounted to almost 13,000,000 lbs., which was a gain of 36% over the previous year. These figures do not include towers for supporting the windmills. It is estimated that from 12,000 to 15,000 separate mills enter the country yearly. Some of these come from abroad, but the number appears to be very small indeed. Regarding the reasons for the demand for windmills in Argentina, including future chances, we quote from Mr. Whelpley's report as follows:

> Almost the entire area of the Argentine Republic—equal to more than a third of that of the United States, including Alaska—is a level and unbroken plain, resembling the prairie country of the Mississippi Valley. Wind is abundant all the year, providing a cheap and

satisfactory power. Even in Buenos Aires, the chief city and the capital of the nation, with a population of 1,250,000, a large number of windmills are in use for pumping purposes in the outlying districts, but their chief use, and the field for future development, is in the vast agricultural and pastoral section of the country, which comprises practically everything except Buenos Aires, and is known in Argentina as the "Camp." Windmills find their largest use in the cattle and sheep grazing sections, where running streams are infrequent and wells must be relied upon to furnish water for the stock.

So far, windmills in Argentina are used for almost nothing except pumping water. Their use as motive power for farm machinery is practically unknown, for the reason that there is little farm machinery in the "Camp," except that used directly in the cultivation and harvesting of crops. . . .

The windmill is about the only economical power available for farm purposes. There is no fear that it will be succeeded presently by gasoline or steam engines, as in some other quarters is already the case. Steam can never be used economically, as there is no coal supply in the country and, except in certain limited districts, little or no wood. Even in Buenos Aires, a seaboard city, coal costs twice as much as in New York, and after it has been hauled by rail and then carted long distances into the interior its price becomes well-nigh prohibitive. For steam traction engines, used in thrashing and similar farm work, corncobs and straw are a customary fuel. Similar difficulties are encountered in introducing the gasoline motor. So far petroleum has not been found in paying quantities in Argentina, and gasoline has to be shipped from North America or the Continent, with an increased cost to the buyer.

The size of mills most used in Argentina ranges from wheels with diameters from 6 to 16 ft. Water is pumped from depths varying from 15 to 300 ft. For the most part steel towers are used, but, as a rule, these "are not more than 20 or 25 ft. high in the 'Camp.'" High and variable winds make strong work necessary. Simple pumps are used for the most part, and the United States has the best of this trade.

Water is stored near the windmills in reservoirs, often holding from 50,000 gals. upwards. The report states that the sides are of sheet-iron and the bottom of hard packed clay.

The import duties on windmills is said to be light, only about 1 ct. per lb., U. S. currency.

Cost and Service of Passenger Cars.

A committee of the Association of Transportation and Car Accounting Officers recently reported* on the cost of passenger cars, the service obtained therefrom and the rentals which should be charged for passenger cars in service. The most interesting of their tabulated data refer to the large increase of first cost of cars which has taken place during the last twenty years. Their figures indicate an increase of about 75%; this is partly balanced by a slight increase in average seating capacity, but making allowance for such increase it is probable that passenger cars cost at least 50% more per seat to-day than twenty years ago.

Figures are also given for all-steel cars. As this type of construction is quite new, the definite figures of cost, depreciation, etc., given by the committee will be interesting in comparison with the figures for wooden cars. The first cost appears to be as much as 50% above that of wooden cars, the seating capacity and service about equal, and the rate of depreciation substantially the same (though the table gives it as 4% against an average of about 3.5% for wooden cars).

The results of the inquiry of the committee are summarized in two tables reproduced herewith as Tables I. and II. Table I. refers to wooden cars and gives the comparison between costs of twenty years ago and to-day. Table II., covering steel cars, and therefore containing only present-day figures, is probably less accurate as to cost and rate of depreciation.

Based on this information the committee has recommended new car-hire rates, adjusting the rates to suit both kind of car and capacity of car. The mileage rates recommended vary from 3 cts. to 5 cts. for ordinary passenger cars; 5 cts. for parlor and dining cars; and 1½ cts. to 5 cts. for baggage, mail and combination cars. Per diem rates are $5 to $8 for ordinary coaches, $8 for dining and parlor cars and $3 to $8 for other cars. Electrically equipped cars (motor cars) are not included in these tables of charges, however.

*Committee on Conducting Passenger Transportation, Chairman, T. J. Tomlinson, Pennsylvania; W. D Dunning, Illinois Central; C. D. Baker, Long Island; and F. A. Gascoigne, Canadian Pacific. Report dated May 17, 1910, circular No. 106 of the Association.

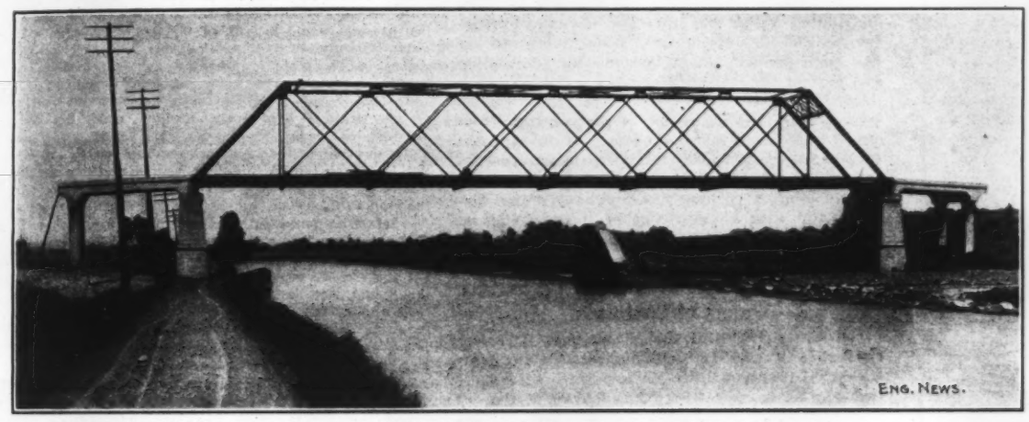


FIG. 4. PARTIALLY COMPLETED BRIDGE WITH PEDESTAL ABUTMENTS.

AN INTEGRATING ENGINE-INDICATOR designed by A. Boettcher, of Hamburg, Germany, is described by him in "Zeitschrift des Vereins deutscher Ingenieure" of July 23, 1910. The instrument in its general lines follows the conventional indicator type. On the flat upper surface of the rotating drum rests the edge of a circular friction disk, running on a spindle set at right angles to the drum axis, the plane of the disk being tangential to the drum. The disk is carried by a yoke linked by bell-crank to the indicator piston in such a way that when the piston is raised, the disk is shifted radially outward on the drum, while when the piston falls the disk is shifted toward the center. The drum is driven by reduction motion from the crosshead just as in any indicator. As it rotates, it causes a rotation of the disk, but the amount of this rotation depends on the radial distance of the disk from center of drum. On the working stroke the disk is far out, and is turned forward proportionately by the forward drum rotation, while on the return stroke the disk is near the center and therefore receives only a small backward rotation. The arrangement evidently results in a net disk rotation strictly proportional to the work done by the steam, and this disk rotation being registered by a counting train the work output of the engine is totalized, revolution for revolution, and can be read off on a numbered dial. To use the instrument, it would be run for a definite measured time, say 10 min., the dial read, before and after, the net register multiplied by an instrumental constant to convert it into horsepower-hours, and this figure divided by the time to give average power output.

The author had such an instrument constructed, and put it through a series of tests to determine its accuracy under different conditions. He gives a discussion of its possible sources of error, and from this supplemented by the tests shows that it is suited for speeds at least up to 300 r. p. m., is practically unaffected by oscillations in the steam line, and has a very satisfactory degree of accuracy. The instrument is able to produce a diagram in the ordinary way whether simultaneously with the registration or after throwing the registering device out of gear, so that a ready means of checking the registry is at hand. The pencil diagram would if course be employed for studying steam distribution, etc., as usual.

TABLE I.—COST AND SERVICE OF WOODEN PASSENGER CARS, AND COMPARISON OF SIZE AND COST WITH CARS OF 20 YEARS AGO.

CLASS OF CARS.	No. of Cars Owned To-day	Initial Cost.		Present Annual Average Mileage Per Car.	Present Average Annual Cost of Maintenance.	Rate of Depreciation Per Year.	Seating Capacity of Cars Carrying Passengers.		Length of Baggage Cars, Etc.	
		Cost 20 Years Ago.	Cost To-day.				20 Years Ago.	To-day.	20 Years Ago.	To-day.
Coaches	10,115	$4,905.06	$6,483.11	42,812	$269.28	3.4%	50 to 72 avg. 61	62 to 86 avg. 75		
Comb. Pass. and Bagg. Cars.	1,791	4,988.99	7,687.44	36,813	489.65	3.25%	15 to 44 avg. 31	30 to 53 avg. 42	45 to 60 ft. avg. 52 ft.	60 to 75 ft. avg. 66 ft. 8 in.
Chair Cars (owned by Railroad)	628	8,494.80	9,796.77	78,650	964.72	3.7%	43 to 60 avg. 48	53 to 85 avg. 68		
Sleeping Cars (owned by Railroad)	367	14,509.14	19,401.00	81,788	697.98	3.33%	25 to 48 avg. 40	30 to 64 avg. 52		
Parlor Cars (owned by Railroad)	329	9,614.71	13,616.67	37,870	556.01	3.4%	24 to 46 avg. 33	30 to 53 avg. 39	avg. 60 ft.	60 to 75 ft. avg. 69 ft.
Tourist Cars (owned by Railroad)	145	5,800.00	11,603.00	68,730	550.00	3.5%		56		
Colonist Cars (owned by Railroad)	304	5,325.00	9,848.50	61,368	547.53	3%	50 to 70 avg. 59	50 to 72 avg. 65		
Baggage Cars	2,749	3,084.18	5,198.68	66,430	508.76	3.5%			40 to 50 ft. avg. 51 ft.	40 to 70 ft. avg. 60 ft.
Express Cars	513	2,634.00	3,968.74	60,808	351.08	3.7%			40 to 50 ft. avg. 46 ft. 8 in.	42 to 60 ft. avg. 52 ft. 3 in.
Dining Cars	435	11,382.89	16,986.35	94,468	866.82	3.4%	20 to 40 avg. 28	30 to 40 avg. 31	60 to 79 ft. avg. 66 ft.	60 to 80 ft. avg. 71 ft.
Comb. Baggage and Mail Cars	1,012	3,455.74	5,760.89	68,971	421.20	3.5%			40 to 60 ft. avg. 52 ft.	50 to 70 ft. avg. 61 ft.
Postal Cars	599	4,225.42	6,948.88	66,011	544.32	3.4%			30 to 64 ft. avg. 54 ft.	50 to 64 ft. avg. 61 ft.
Postal Storage Cars	70	3,749.89	5,403.72	102,794	506.22	4%			40 to 64 ft. avg. 55 ft.	60 to 64 ft. avg. 61 ft. 5 in.

TABLE II.—COST AND SERVICE OF ALL STEEL PASSENGER CARS.

Class of Cars.	No. of Cars Owned	Cost.	Present Annual Average Mileage Per Car.	Present Average Annual Cost of Maintenance.	Rate of Depreciation Per Year.	Seating Capacity of Cars Carrying Passengers.	Length of Baggage Cars, Etc.
Coaches—							
Regular Non-Motor. Road B.	300	$15,904.61	48,956	* †	4% ‡	88	69 ft. 7⅝ in.
" D.	51	11,798.00	31,490			70	64 ft. 0¾ in.
" Regular Motor. Road D.	50	19,798.00					
" Suburban Non-Motor. Road E.	55	8,823.00				64	
" Suburban Motor. Road D.	132	12,313.49	28,438			52	51 ft. 4 in.
" E.	125	13,080.00				64	
" Experimental Non-Motor. Road A.	1	11,800.00	*31,075			72	
" C.	1	15,195.72				78	
Combined Passenger and Baggage Cars. Road B.	51	14,500.00	46,592		4% ‡	42	70 ft. 4⅞ in.
Baggage Cars— Road B.	20	10,500.00	67,780		4% ‡		60 ft. 3¼ in.
" A.	6	6,100.00					60 ft. 1¼ in.
Dining Cars— Road B.	47	21,400.00	105,372		4% ‡	30	71 ft. 8⅛ in.
Postal Cars— Road A.	1	8,850.00	44,427				60 ft. 1¼ in.
" B.	47	14,500.00	107,932		4% ‡		70 ft. 9¾ in.
Postal Storage Cars— Road B.	27	11,000.00	134,972		4% ‡		60 ft. 3¼ in.

* Car was in shops from January 11, 1909, to April 30, 1909.
*† No record kept.
‡ Interest 5 per cent.

Smoke-Abatement Legislation for Boston and Vicinity.

A bill designed to bring about a suppression of the smoke nuisance in and near Boston was passed by the Massachusetts Legislature on June 15. The law nominally went into effect on July 1, but, owing to many details of appointing inspectors and otherwise making the requirements effective it is held that not before Sept. 1 will the full force of the new law be felt.

The bill was drawn by the Committee on Fuel Supply of the Chamber of Commerce, after a long study of the local problems. The statute includes several features which, it is claimed have not appeared before in smoke ordinances here or abroad. For instance, chimneys or stacks are classified according to the inside diameter at the top. Also a board is provided, serving without pay, to see that the law is enforced and to assist owners of boiler plants to comply with the new requirements.

The old law provided that dense smoke should not be allowed to escape from any building or premises, except in the case of locomotives or public-service power plants or of wood-burning plants, for more than six minutes in any one hour of the day or night. The present statute is intended to remove several defects in the old law; for instance what constituted a dense smoke has been a question and the exception of railroads and public-service power plants has left large offenders uncontrolled. The density of smoke is to be judged under the new law by comparison with Ringelmann charts, as published and used by the U. S. Geological Survey. The classification of stacks is into three general classes; (a) of stationary plants, (b) of marine boilers, (c) of locomotives. In the statutes six classes are mentioned but Classes I to III are for stationary plants and IV and V are for vessels. The statute classification reads as follows:

Class I includes all fixed or stationary stacks having an inside area at the top not exceeding the area of a circle 5 ft. in diameter.

Class II includes all fixed or stationary stacks having an inside area at the top greater than the area of a circle 5 ft. in diameter but not exceeding the area of a circle 10 ft. in diameter.

Class III includes all fixed or stationary stacks having an inside area at the top greater than the area of a circle 10 ft. in diameter.

Class IV includes all stacks of vessels having an inside area at the top not exceeding the area of a circle 4 ft. in diameter.

Class V includes all stacks of vessels having an inside area at the top greater than the area of a circle 4 ft. in diameter.

Class VI includes all stacks on steam locomotives.

The accompanying table reprinted from the "Acts of 1910" shows the density of smoke which may be emitted from the various classes of stacks as provided in the law and the duration of such emission of smoke. From this table it will be seen that the smaller stacks are restricted as to the density of smoke which may be emitted. It was held that a 4-ft. stack might emit smoke say of a density equal to No. 2 on the chart and a 12-ft. stack might be emitting smoke containing the same number of black particles per cubic foot yet from visual evidence the 12-ft. stack would be the greater offender because there is a column of smoke 12-ft. thick to be matched as against one only 4-ft. thick in the case of the smaller stack. Marine and locomotive stacks have not been placed under the same restrictions as it was considered that their operating conditions make it less easy to prevent smoke and the restriction justified for a stationary plant would impose a hardship on the operators of locomotives and marine boilers.

The Board may order any person or corporation complained of to comply with the provisions of the act and may enforce its order by legal proceedings. Violations of the Board's orders may be punished by a fine of not less than $10 or more than $50 for the first offense. For a second offense the penalty is doubled.

Temporary permits for the emission of smoke contrary to the provisions of the act may be granted by the Board for periods of six months to any person satisfying the Board that changes or improvements will be made to comply with the law. After Dec. 1, 1910, no such permits are to be issued unless public convenience requires it.

The district in which these provisions apply is defined in the statute thus:

That part of Boston harbor lying westerly of a line drawn from the southeastern point of Deer Island to the northeastern point of Long Island and the territory comprised within the cities of Boston, Cambridge, Somerville, Everett and Chelsea and the town of Brookline.

The expense of carrying out the law is to be distributed among the cities and towns in proportion to the amounts of their respective state tax and such apportionment becomes an addition to and part of the state taxes.

One paid inspector is provided for and he is intended to occupy a position of prosecuting attorney, investigator and instructor. It is expected that a salary of $3,600 will be paid in order to secure an engineer with practical experience in the working of various types of boilers and furnaces and with a knowledge of the problems of burning various fuels.

TABLE SHOWING THE DENSITY OF SMOKE, IN ACCORDANCE WITH THE RINGELMANN CHART, WHICH MAY BE EMITTED AND THE DURATION OF SUCH EMISSION, FROM THE VARIOUS CLASSES OF STACKS AS PROVIDED IN CHAPTER 651, SECTION 2, ACTS OF 1910, MASSACHUSETTS.

Classes	I		II		III		IV	
	Chart No.	Mins.	Chart No.	Mins.	Chart No.	Mins.	Chart No.	Mins.
1910	3	6	4	5	4	10	4	9
1911	3	4	3	10	3 including 4	20 including 5	3	12
1912	2	8	3	6	2 including 3	30 including 10	3	7
1913	2	6	3	3	2 including 3	25 including 5	3	3

Classes.	V		VI			VI		
	Chart No.	Mins.	Chart No.	No. seconds in 5-min. periods.		Chart No.	No. seconds in 5-min. periods.	
1910	4	12	3	40		3	50	
1911	3	15	3	30		3	40	
1912	3	9	3	20		3	30	
1913	3	5	3	20		3	30	

Locomotives moving trains of six cars or more.

The Industrial Value of Some of the Surface Waters of California.

One of the latest of the Water-Supply Papers (No. 237) of the U. S. Geological Survey deals with the quality of the surface waters of California. After reviewing the characteristics of various streams and presenting the results of detailed chemical analyses, the paper concludes with a summary designed to present in brief the economic value of the waters of the state. We quote from the text and reproduce one of the tables as follows:

The average mineral content of the 37 rivers studied in detail is 368 parts per million, the average in the humid regions being 165 parts and in the semiarid regions 628 parts. The bicarbonate radicle is predominant in most of the waters. Its place is taken by the sulphate radicle in the water from the regions of least rainfall. The average amount of the bicarbonate radicle, computed as normal carbonate, is 27.3% of the anhydrous residue, and the amount of this constituent is never abnormally high as compared with that found in surface waters of other sections of the United States; but in the waters of the more arid regions its relative amount sinks into insignificance, averaging only 5.8% in Santa Maria River. The sulphate radicle fluctuates in inverse ratio to the bicarbonate radicle. It forms 58.5% of the residue of the water from Santa Maria River, and in the humid regions it is as low as 10.2% in the average of Santa Ana River at Mentone in 1906. In examination of the "spot" samples, the lowest carbonate and the highest sulphate percentages were found in the same stream, Gaviota Creek, where carbonates were only 3.1% and sulphates were 60.3% of the total anhydrous residue.

The accompanying table shows the average value of the waters examined with reference to their steaming qualities. The results obtained also serve to indicate the qualities of the water for many other purposes, and may be assumed to indicate the economic value of the waters. The properties considered are the tendency to foam, to prime, and to cause corrosion, the amount of scale deposited by the water, and the nature of the scale. The method of study was that outlined by Stabler,* the suspended matter not being considered, it being assumed that this would be settled or filtered out if the water were to be put to industrial use. The values are averages for the period of examination, and figures are not given.

Under foaming the following classification was employed: Non-foaming indicates that the water could be used for one week or more in a locomotive boiler without foaming; semi-foaming, that it could be used for two days to one week under the same conditions without foaming; and foaming that it would cause foaming in less than two days. Similarly, classification of the corrosive tendency as non-corrosive when there was no chemical evidence that corrosion of metals might occur; semi-corrosive when certain conditions of its use might cause corrosion; and corrosive if a positive tendency to produce corrosion existed. Under scale, if not over 1 lb. of scale would be deposited for each 1,000 gals., the water is classed as giving very little scale; if between 1 and 2 lbs. of scale would be deposited per 1,000 gals., the water is classed as producing little scale; if between 2 and 4 lbs. of scale would result from its use, the water is classed as giving much scale; and if over 4 lbs. of scale would deposit on the use of 1,000 gals. of water it is classed as depositing very much scale. The nature of the scale is described as soft, medium or hard, according to the ratio of hard scale to total scale formed, soft scale containing not over one-quarter of the total as hard scale, medium scale, not over one-half or under one-quarter, and hard scale not under one-half of the total scale as hard scale.

It is apparent from this classification that the surface waters of California are in general hard; that none of the semiarid region waters are of excellent quality for industrial purposes; that the Sierra rivers have a tendency to produce a small amount of hard scale in the boilers; that the number of non-foaming waters is small, but the number of waters bad in this respect is less in the humid than in the semi-arid region; and that the softest and best waters for steaming purposes are those in the orange belt of southern California.

The waters from the Gabilan and Diablo ranges and from Santa Maria River are classed as foaming. The Santa Maria furnishes the sole example of corrosive water, though others, notably Estrella River, show strong tendency to cause corrosion under certain circumstances.

Owens River, between Round Valley and Charlies Butte, shows a change from a poor water depositing much hard scale in boilers to a far better water producing but little medium scale. This is the result of inflow of softer water, less strongly mineralized water between the points of collection.

*Stabler, Herman, The Mineral Analysis of Water for Industrial Purposes and Its Interpretation by the Engineer: Eng. News, Vol. 60, 1908, p. 356.

THE INDUSTRIAL VALUES OF CALIFORNIA SURFACE WATERS.

Stream.	Priming	Corrosion.	Scale.	Nature of scale.	Nature of drainage basin.
Alameda Creek	Semifoaming	Semicorrosive	Much	Medium.	Humid.
American River	Nonfoaming	do	Very little	do	Do
Arroyo Seco	Semifoaming	Noncorrosive	Little	do	Semiarid.
Cache Creek	do	do	Very little	Hard	Humid
Cottonwood Creek	do	do	Much	Medium.	Semiarid.
Estrella River	Foaming	Semicorrosive	do	Hard	Do
Feather River	Nonfoaming	do	Very little	Medium.	Humid.
Kern River	do	do	do	do	Do
Malibu Creek	Semifoaming	do	Much	Hard	Semiarid.
Merced River	Nonfoaming	do	Very little	Medium.	Humid.
Mokelumne River	do	do	do	do	Do.
Nacimiento River	Semifoaming	do	Little	Hard	Semiarid.
Owens River, Charlies Butte	do	Noncorrosive	do	Medium.	Do
Owens River, Round Valley	do	do	Much	Hard	Do
Russian River	Nonfoaming	Semicorrosive	Very little	Medium.	Humid.
Sacramento River, 1906	do	do	do	do	Do
Sacramento River, 1908	do	do	do	do	Do.
Salinas River	Semifoaming	do	Much	Hard	Semiarid.
San Antonio River	do	do	Little	Medium.	Do
San Benito River	Foaming	do	Much	do	Do
San Gabriel River, Azusa	Nonfoaming	Noncorrosive	Little	Soft	Humid
San Gabriel River, Rivera	do	do	do	do	Do
San Joaquin River, 1906	Semifoaming	Semicorrosive	Very little	Hard	Do.
San Joaquin River, 1908	do	do	do	do	Do.
San Lorenzo River	do	do	Little	Medium.	Do
San Luis Rey River	do	do	do	do	Semiarid.
Santa Ana River, Corona	do	Noncorrosive	Much	Soft	Humid
Santa Ana River, Mentone, 1906	Nonfoaming	Semicorrosive	Very little	do	Do.
Santa Ana River, Mentone, 1908	do	Noncorrosive	do	Medium.	Do.
Santa Maria River	Foaming	Corrosive	Very much	Hard	Semiarid.
Santa Ynez River, 1906	Semifoaming	Semicorrosive	Much	do	Do
Santa Ynez River, 1908	do	do	do	do	Do
Santa Ysabel Creek	do	do	Little	Medium.	Do
Stanislaus River	Nonfoaming	do	Very little	do	Humid
Tuolumne River	do	do	do	do	Do
Ventura River	Semifoaming	do	Much	Hard	Semiarid.
Yuba River	Nonfoaming	do	Very little	Medium.	Humid.

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The ever-present sentiment in engineering circles that the professional status of the engineer should be protected or guarded in some way, to prevent both the spread of quackery and the lowering of the standards of professional conduct, has come to the surface in a new form. London engineers are proposing to form a purely *professional* association, a society which is not to concern itself with reading and discussing technical papers but solely with cultivating professional objects. A meeting of interested engineers was held a few weeks ago to discuss the proposition, and a committee was there established for drawing up rules and taking further steps toward organization.

Apparently the proposed body, if actually formed, will be a sort of Bar Association in embryo, for its expressed object is to prevent the engagement of unqualified persons as Consulting Engineers. It is alleged that when towns or other governing authorities have occasion to retain an engineer, unqualified persons solicit the engagement and often succeed in obtaining it, to the loss of the public as well as of the reputable consulting engineers.

A distinctive feature of this movement is that it is restricted to Consulting Engineers. It will be remembered that all other existing or proposed devices for regulating the professional status of engineers apply to a much broader class. In fact one (American) organization exists which takes in only subordinate employees and excludes not only independent engineers but also every employing engineer, even if he be an employee himself (as for example a department head), and even if he employ only a draftsman. This body is at one end of the scale, the proposed London association at the other extreme. But evidently both are closely similar in tendency; they constitute unionizing attempts, for the protection of the member's bread and butter.

We have no doubt that if the Association of Consulting Engineers goes through, it will find important work to do. Complaints are frequent that the existing societies of engineers have not done much in the way of determining professional questions, and have in fact generally declined to concern themselves with professional matters. Engineers in this country are familiar with such complaints, and as for England we have a direct demonstration in the proposal to found a professional association, in spite of the existence of more and stronger societies than we possess in this country. Although the standards of membership are stricter and more strictly applied in the English societies than in ours, they do not appear to have accomplished better professional protection.

The situation is a curious commentary on the efficiency of our engineering societies. Why should not a great and influential body, in which engineers are joined together for the care of their common interests, devote part of its energies to questions that concern engineers as a whole, that is to say professional questions? Is it not just as profitable to spend some time on discussion of rules or principles of professional conduct as to argue wordily over the precise degree of continuity probably prevailing in concrete beams? If the society establishes a high standard of professional qualification, should it not also endeavor to obtain general public recognition of this standard?

Out of the mass of somewhat contradictory ideas of what constitutes progress in engineering education, one proposition at least stands out as universally accepted—that the theoretical instruction must be supplemented by commercial practice and industrial discipline before the would-be engineer can give really satisfactory service to his employer. Moreover, it is recognized that this proposition is not in conflict with another accepted guiding principle—that the school is the place for teaching only that which can be secured elsewhere or afterwards with difficulty or not at all.

This desired alinement of theory and practice, this correction of college freedom with industrial discipline, this contact with vigorous workmen as well as learned professors, some believe is best obtained in large doses, or even all at once immediately after graduation. We remember in this connection, however, that the boys, who are older engineers now, and who necessarily so postponed this supplemental training were most unhappy for a period varying from a few months to a couple of years, while the hardest of lessons were being learned.

Local conditions and an incidental compromise of desirable ends seem to dictate the duration of the apprentice periods. Possibly the training comes with less hardship on the shops and apprentices, if weekly periods are arranged. This, of course, is practicable only in or near a large industrial center, and naturally the farther the school is from such centers, the longer the working period tends to become.

We have previously noted (Eng. News, July 18, 1907, p. 67; July 9, 1908, p. 37) how the problem was approached by the University of Cincinnati. One of the chief factors contributing to the success of the Cincinnati plans, in securing the ready cooperation of the factory managers, is adherence to the idea that the apprentices must be made profitable for the shop. In another part of this issue, the later development of the Cincinnati courses are frankly discussed by Dean Schneider and it is at once evident that not only have the students profited but also there has been a healthy reaction on the engineering college of the University. Teachers, courses and methods have had to withstand the severe scrutiny of practical men. Evidently the college apprentices have been doing some foolish things in the shop and the professors have been blamed for not successfully implanting fundamental governing principles. As one result, an attempt has been made to tie together the separate courses so that the inter-relations between one subject and another are treated by some one closely identified with the related subject. Also a new type of instructor has been introduced, "the Coordinator," whose duty is regularly to show the boys how the practice follows the theory, and how certain systematic methods of work are necessary for economy. Under their guidance a fund of illustrative matter is being catalogued as found in the daily work of the apprentices and directly used in presenting mechanics, thermodynamics, machine design, etc. The old nerve-racking examinations have been abolished for the cooperative students and grading is now based on their weekly performance reports.

We are surprised to learn that Dean Schneider has received, from some of his prospective students and from his correspondence with other teachers, the impression that a considerable proportion of engineering graduates and professors sanction excluding engineering students from contact with workingmen. We can certify that many leaders of the engineering profession and the most successful and broad-minded teachers have repeatedly emphasized belief in the great good that comes from first-hand knowledge of the worlds common work and daily contact with the workers. We must believe that the successful and democratic engineers and teachers have merely not felt the need of expressing further approval of an accepted idea while Dean Schneider's mail has been from men of smaller vision and limited usefulness. It is particularly worthy of notice here, though it might have been expected, that these apprentices have acquired a desire for broader training, both in engineering and in "cultural" subjects.

It is manifest that there can be only one president, one general manager and only one chief engineer for each important concern while there must be scores of educated and trained men willing to do much the same thing each day, thoroughly and skillfully but quite unapplauded. The younger engineering graduates chafe under such conditions and the unrest in their minds may be traced to an impatience to rise. Perhaps this is because our schools have tended more to emphasize the end of education and the object of special training as "to get on top" (for we have always been told that "there is room at the top") rather than to "enjoy a useful life."

This view does not necessarily imply lack of ambition, for substantial enduring advancement may be expected as the result of quiet, concentrated attention to technical work in hand with healthy relaxation at proper periods, fully as much as the result of unremitting bustle and solicitation—assuming real technical ability in both cases. Our technical courses have been pretty sharply criticized these last few years, because they failed to impress on boys, during their formative years, the need of clean living and clear thinking or the benefits of habits of justice, ease and happiness in work, or that high ideals may be held although not paraded for public scrutiny. It would seem as though some scheme of virile apprenticeship in weekly, monthly or even longer periods should help greatly and perhaps even be essential in quickly acquiring these few most desirable habits. Engineering teachers generally can no better prepare themselves to approach the problem than by thoughtfully considering the Cincinnati developments.

Rate raising on the part of public-service corporations meets with no little opposition in these days. The proposed increase in railway freight rates and in the passenger rates paid by commuters traveling to and from New York have attracted widespread attention, but outside of Philadelphia and vicinity little has been heard of an interesting water-rate war which has been waging there for a number of weeks past. This is not surprising in view of the relatively local character of this rate war, but the principles involved are of more than local interest.

It appears that no less than 73 suburbs of Philadelphia are virtually dependent for their water-supply upon the Springfield Consolidated Water Co., although each community, under the Pennsylvania statutes, is nominally served by an independent water corporation. In June the operating company, or its subsidiary members, appears to have notified its consumers that advances in rates would go into effect on July 1. Reports state that these advances range from 33

to 100% and that the "minimum rate" for a single household is to be increased in some or all of the communities from $10 to $18 per year.

Rightly or wrongly, the water consumers of these municipalities regarded the increase in rates as an outrage. Public indignation meetings have been held, local and general associations for protest organized, lawyers engaged, and in one or more instances the protesting consumers have begun legal proceedings to prevent the enforcement of the new rates.

Attempts to judge the merits of the case are complicated, it is alleged, by the fact that not only are the numerous local water companies controlled by a consolidated company, but also that the stock of the latter is in the control, wholly or largely, of the American Pipe & Construction Co., of Philadelphia, manufacturers of the so-called Phipps' hydraulic pipe, a cement pipe largely used in the construction of the various works. The water consumers allege that the last-named company, through the supply of pipe at high prices, has greatly swelled the construction cost of the various works, and thus put upon a fictitious basis the claims of the companies that their revenues must be increased if they are to pay operating expense, to say nothing of proper dividends on their investments.

Unquestionably, the various companies involved in this controversy are entitled to adequate returns on all capital legitimately invested in the works supplying these Philadelphia suburbs with water. But are these water consumers to be blamed for strenuously resisting what appears to them to be a sudden, arbitrary, outrageous increase in one of the prime necessities of urban or suburban life? As far as we understand, the water companies have given no facts to justify the increase in prices further than the common general assertion in such cases to the effect that existing rates afford an insufficient return on the capital invested. The time has passed when intelligent citizens will accept assertions of this kind unsupported by figures that will bear close scrutiny of those competent to judge their trustworthiness. The courts are open to appeal, but no private citizen ought to be compelled to bear the expense necessary to fight a large corporation in order to secure just rates for services rendered by a company enjoying a natural monopoly, like a municipal water-supply. Other states, as yet relatively few in numbers, have put the control of rates charged for the services rendered by municipal public-service corporations in the hands of state commissions. The incident outlined above would seem to indicate that it is high time for Pennsylvania to do the same. That state already has a water-supply commission, but its powers and duties are limited in scope and appear to have no relation whatever to such a case as the one before us.

The outcome of this water-war will be awaited with interest. It seems probable that little further will be done until the first quarter's rates under the new schedules fall due, which will be some weeks hence. For the benefit of anyone interested, we may note in conclusion that the committee organized in the interest of the citizens by the water consumers is known as the Central Water-Rate Protest Committee, and that it has been holding meetings in the offices of Mr. Hubert B. Powell, Betz Bldg., Philadelphia.

Large-Size Timber Tests.

For many years the design of timber structures was wholly empirical. There was an apparently unending supply of the material and the time and effort necessary for its economic use was hardly worth the trouble, so each builder used sizes known, from previous experience, to be strong under similar conditions and where conditions were new added enough to make more than certain. Wood was cheap, and a few thousand feet in a bridge or a building added only a negligible cost. As the supply gradually decreased and the price consequently went up the use of timber diminished, because other materials could be used whose slightly higher cost was more than balanced by their much longer life. There are, however, still many cases where timber can be used to advantage in large structures and the interest in it as structural material has by no means disappeared, as the valuable studies by the Forest Service of the United States and by various technical and trade societies will testify.

As the diminution in the supply of wood was realized, engineers began to put more care and thought into the design of timber structures. The first step toward this more careful design was necessarily the investigation of the strength properties of the timber. Many such tests had been made and values established which were generally accepted as correct, entered in textbooks and used by the designers of timber structures. On account of the known variability in wood structure, the tendency of the individual piece to have knots, cracks or checks, possibly also the known difficulty of effective inspection, in fact on account of the obvious defects of an organic material, it has always been the custom in establishing unit safe stresses from rupturing stresses, as determined from tests, to apply to timber much higher factors of safety than in materials of a more consistent nature. Safety factors of from six to ten have been by no means uncommon, while in steel and concrete from two to four are generally used. But the peculiarities of the wood itself are not the only factors that affect the safe unit stresses. Such stresses must be deduced from rupturing stresses determined in tests, and it is in these tests that another source of error lies. Examination of ultimate stresses on timber given in any but the most modern texts will show not only a very great variation among authorities but also values which, in the light of later tests and of experience in structures, seem abnormally high. In the search for a reason for this, one of the sources of trouble that early suggests itself is the size of the test-pieces. In every sort of material testing the importance of large size pieces is being recognized. The fact that unit stress is not proportionate to section has been often shown in pieces made up of smaller pieces bound together by some supposedly efficient tie, such for instance as a built-up steel member. This principle has been carried further and applied to non-homogeneous bodies, such as concrete. Wood is even more subject to this provision than either of the other materials mentioned, because being of a fibrous nature, subject to many cracks and checks, integrity of a large size piece can but infrequently be predicated from the condition of a portion cut from that piece.

Investigation of tests on wood in the past will show that the test pieces have, for the most part, been much smaller than ordinary structural sizes. In the determination of bearing, tension or short column compression this has possibly not been the case, for the structural details affected by such stresses are usually so small that full-size pieces could readily be used in test. But when it comes to stringers or beams, or even columns, up to a few years ago tests were made on pieces which would hardly ever be used in a bridge or building of fair size. Prof. Gaetano Lanza, in a discussion before the International Engineering Congress in 1904, gave in some detail the work that had been done up to that time on the full-size testing of timber. His investigations show that, compared with the great amount of data on small pieces, the full-size piece data are most meager. Tests have been made, but there is need for many more before there can be established any safe unit stresses of definite validity. Among the latest of such tests and typical of those desirable are some recently made under the direction of Prof. A. N. Talbot of the University of Illinois, the results of which have been published as a bulletin* of the Engineering Experiment station of that University.

As the Bulletin contains some 77 pages and a number of curves and tables, it is too long even to abstract here, but some of its findings may be alluded to as throwing light upon timber design as well as upon the relation between large and small size specimens.

*Tests of timber beams by Arthur N. Talbot, Bulletin No. 41, University of Illinois, Engineering Experiment Station.

The tests were made upon 112 sticks varying from 8 × 16 ins. × 15 ft. to 7 × 12 ins. × 4 ft. in size and on longleaf, shortleaf and loblolly pine and Douglas fir. The period of seasoning varied from 4 to 18 months (giving moisture contents of from 16 to 39%) with one lot of Douglas fir sticks some 11 years old; a portion of the beams were creosoted but the results from these will not be considered here. Tests were made upon the full size sticks as beams loaded at the third points and upon small pieces cut from the large sticks both as beams 3 × 3 in. × 4 ins. and in shear upon blocks about 6 × 8 × 12 ins. in size. The beams were so designed that they would fail in horizontal shear and in many cases they did so fail, though some beams failed in tension in the lower fibers.

While of course no specific deductions should be made without careful reference to the individual beam performances, as reported in the text of the Bulletin, the conclusions made by Prof. Talbot cover the general results of the tests. These conclusions, slightly abbreviated, are as follows:

The preponderance of failures in horizontal shear is very marked in every series of tests. The results emphasize the importance of the shearing resistance of the wood in beams of the dimensions of those tested. The cross-breaking failures were in sticks having mid knots and cross grain. A few of these defective sticks would not be called merchantable timber, but many of them might pass inspection as it is usually made. The influence of defects is very marked. Knots, cross grain, and seasoning checks act to give low strength. Any tendency to relax requirements and inspection should be avoided, unless accompanied with the use of lower working stresses.

The horizontal shearing resistance developed in the stringers is low in every series of tests. Comparatively little difference in shearing resistance is found for the different kinds and conditions of wood, for in the clear sticks of the stronger woods large seasoning checks act to prevent the utilization of the full cross-breaking strength of the timber.

For the cross-breaking failures the fiber stress developed was also generally low.

The elastic limit of the beams is seriously affected by defects like knots and cross grain. However, in general, the fiber stress at the elastic limit is proportionally high, the ratio to the fiber stress at failure averaging from 0.67 to 0.90 for the several series of tests.

The strength developed in the small test beams cut from the top and bottom of the stringers averages from 70% to 100% higher than that obtained in the stringers, and the results show the futility of taking tests of small sticks as a criterion of the strength of full-size structural timber. The shearing strength developed in the stringers was 60% to 100% of the shearing strength developed in shear blocks cut from the uninjured end of the stringers at mid-depth and having their full thickness; but these strengths of the shear blocks are much less than will be obtained on small pieces of selected timber.

It is evident that the defects found in structural timber have a strong influence on strength and that rigid inspection should be given.

These results may not be at all novel to those who have followed the more recent developments in timber testing, but they are so typical of the large-size timber test that they are worth the study of the engineer who has been accepting as correct old unit values derived from small size tests.

The more recently established unit values, such values as have been adopted by some of the technical associations, recognize these lowered stresses, but even the latest of these are still a trifle higher than would be warranted from Prof. Talbot's limited tests. We have prepared below a table on three kinds of wood from Prof. Talbot's figures and from the unit stresses as recommended by the Committee on Wooden Bridges and Trestles of the American Railway Engineering and Maintenance of Way Association as reported in 1909. This table gives ultimate stress as observed by Prof. Talbot on large and small size pieces, on longleaf and shortleaf pine and Douglas fir in bending, horizontal shear in bending and shear parallel to the grain under direct pressure. Similar figures are given for ultimate and safe unit stresses as prescribed by the committee named above. The figures taken from the Illinois tests are averages of a number of pieces and cannot of course be considered as absolute for all conditions and kinds of woods, but as a

designer cannot be expected to know the precise condition of the timber going into his structure, the average figures given in the table taken from tests of pieces that would all pass ordinary merchantable inspection, should represent a safe average from which to establish a designing stress. All the pine sticks had been seasoned for from 12 to 18 months and the individual figures show that this difference in age had little effect on the strength. One set of fir sticks was 11 years old while the other was only partly seasoned and although this had little effect on the large size pieces, in the small sizes the old fir shows a strength some 20% greater than the new. No shortleaf pine sticks were tested in small pieces. The committee's stresses are based on a "green" or ordinary air-dried timber and it is stated that they may "be increased by 25% for highway bridges and 50% for buildings, or where the timber is protected from the weather and not subjected to impact."

	Ultimate Stress.			Safe Stress.
	U. of I. Tests. Large Size	U. of I. Tests. Small Size	Am.Ry. Eng. & M.of W. Assoc.	Am.Ry. Eng. & M.of W. Assoc.
Longleaf pine.				
Bend. Ex. Fib..	5,389	8,545	6,500	1,300
Hor. Shr. in Bend. ..	365	532	300	120
Shr. Par. to Grain....	—	430	720	180
Shortleaf pine.				
Bend. Ex. Fib.....	4,886	—	5,600	1,100
Hor. Shr. in Bend.....	364	—	330	130
Shr. Par. to Grain....	—	—	710	170
Douglas fir.				
Bend. Ex. Fib.....	4,414	8,322	6,100	1,200
Hor. Shr. in Bend.....	302	515	270	110
Shr. Par. to Grain....	—	400	690	170

The table shows that (1) the small size pieces have unit values from 60% to 100% larger than do the large beams; (2), the ultimate values for bending in the outer fiber are some 15% to 20% less in Talbot's large size tests than in the committee report; (3), the horizontal shear in bending is slightly larger in the tests than in the committee report and (4), the direct shear parallel to the grain is much less in the tests than in the report. The safety factors of the report are 5 for outer fiber bending, 2½ for horizontal shear and 4 for direct shear, but if the Illinois tests were used as criteria for the factors, these figures would change to 4.1, 2.8 and 2.4, respectively, which are low values for so variable a material as wood.

This table is not shown here to indicate any fault in the unit values prescribed by the committee of the Maintenance of Way Association—indeed, in view of some of the high values for timber that can be found in some text-books, the unit stresses compiled by the committee are quite conservative and indicate due regard for the latest and best tests. The table does have a value, though, as an example of what one restricted set of tests shows as to the strength of timber and the necessity for large size tests to determine unit values. This is not a new discovery. Its truth was discovered some years ago and it was clearly stated both by Prof. W. K. Hatt in a discussion before the American Society of Civil Engineers in 1903 and by Prof. Lanza before the International Engineering Congress in 1904, but for the benefit of the designers who use unit stresses determined from tests it should bear stating again.

LETTERS TO THE EDITOR.

Further Light on the Failure of the Long Beach Pier.

Sir: The letter of Mr. J. S. Armstrong published in your issue of Aug. 4, 1910, p. 131, in regard to the failure of the Long Beach pier, as well as the article of Prof. Waterbury appearing in the issue of July 21, p. 67, were of necessity quite interesting to us.

It befell that in January, 1908, we were called upon to make a report upon the condition of the Long Beach pier at that time. A portion of our report was as follows:

Furthermore, we do not think the concrete was placed in accordance with the specifications in that there is ample evidence that the caissons were not pumped out before the concrete was placed. This is shown by the segregation of the aggregate, the concrete having evidently been deposited through water, when the heavier rock settled first and then in successive layers down to fine sand, the cement being washed out and held in suspension. This, of course, destroys the bonding of the material together by the cement and accounts for the present porous and friable condition of the concrete.

After making this report, a member of our firm, who is a resident of Long Beach, was repeatedly stopped on the street and told of some of the happenings during the construction of the pier.

The specifications for the construction of this pier called for the placing of the caissons, the same to be pumped out and filled with the concrete, after driving the piling. The first few caissons near the shore were pumped out, but in view of the fact that these caissons simply rested on a sand bottom, the contractor evidently found it a rather difficult matter to pump out the water as they went farther out to sea. At any rate, the caissons were not pumped out and the concrete was deposited through—not under—from 20 to 30 ft. of water, with the result as above mentioned. The caissons were filled in this manner up to about mean tide level and then left to stand. The result is that at this level there is a layer of the residue of Portland cement, which becomes easily soluble when the wooden staves have fallen off under action of the teredos.

The above may clear up some of the difficulties in the minds of Mr. Armstrong and Prof. Waterbury.

Yours very truly,

Mayberry & Parker.

Los Angeles, Cal., Aug. 9, 1910.

Pavement Crowns.

Sir: In a paper prepared on the subject of pavement crowns by the undersigned for the Convention of the American Society of Municipal Improvements held in Little Rock, Ark., in November, 1909 (Eng. News, Dec. 2, 1909, p. 611; also June 30, 1910, p. 759), a general rule given for monolithic pavements with a roughened or grainy surface provided a crown of ¼-in. per ft. of width of roadway between tracks and a fall of one-third between crown and quarter and two-thirds between quarter and gutter. The paper gave variations for peculiar conditions such as steep grades, streets having railroad tracks or having curb on one side at a higher level than the other side of the street.

In the discussion following the reading of the paper, it was criticized as not providing points between the quarter and gutter and between the quarter and crown. While these "midquarter" points are quite unnecessary unless the streets are wider than 40 ft. the criticism of the omission was well taken and the writer replied as it now appears with insufficient thought as follows:

With streets, say 40 ft. wide, I believe my rule is sufficient and no intermediate points are necessary or advisable. If the streets were of unusual width, the rule I would follow would be first to find the crown, and then find the quarter and intermediate points by sighting across with a "T." If the street is of such width that you want intermediate stakes, make the same division between the quarter and the curb as between the quarter and the crown; that is, let two-thirds of a total fall be in the half nearest the curb and one-third in the half nearest the crown.

Now Mr. G. B. Zahniser, of Newcastle, Pa., kindly calls the writer's attention to the fact that this change provides a "straight line from the crown midquarter point to the curb midquarter point." Mr. Zahniser agrees with the writer's cardinal rules above referred to, but as to midquarter points suggests the following rule, which the writer heartily endorses:

First drop, one-eighth the crown at the crown-midquarter point.
Second drop, one-third the crown at the quarter point.
Third drop, five-eighths the crown at the curb-midquarter point.

The writer's rule, thus modified by Mr. Zahniser, would give, for example, the following dimensions on a nearly flat street with roadway 80 ft. wide between gutters, on streets having no tracks:

Crown, 20 ins. above gutter.
First drop, one-eighth of the crown at the crown-midquarter point, i. e., 2½ ins. below the crown.
Second drop, one-third the crown at the quarter point, i. e., 6⅔ ins. below the crown.
Third drop, five-eighths of the crown at the curb-midquarter point, i. e., 12½ ins. below the crown.

Very truly yours,

Geo. C. Warren.

58 Temple Place, Boston, Mass., Aug. 11, 1910.

[It should be noted that Mr. Zahniser called attention to this revised formula in an article in Engineering News, May 5, 1910, p. 516, entitled "Suggestions for a Rational Formula for Street Pavement Crowns."—Ed.]

PROGRESS OF CIVIC CENTERS in 16 American cities is summarized in "Denver Municipal Facts," for July 30, 1910. In Cleveland, 75% of the land needed for the proposed civic center has been acquired. The Cleveland civic center will be "one of the largest decided upon by any city." Boston, Milwaukee, Philadelphia, Madison, Wis., Hartford, Washington, Rochester, N. Y., Portland, Ore., St. Paul, Buffalo, Columbus, Ohio, St. Louis, Providence, Springfield, Mass., have civic center projects in various stages of promotion or actual achievement.

The Joint Meeting of the British Institution and American Society of Mechanical Engineers at Birmingham and London.

The joint meeting of the Institution of Mechanical Engineers and the American Society of Mechanical Engineers opened at Birmingham, England, on the morning of July 26 with an attendance close to 700, the party of the American Society numbering about 160. The sessions were transferred to London on July 29. It has been stated that the meetings opened on July 26, but in reality they commenced, as far as the American Society was concerned, with the sailing of the White Star liner "Celtic" on July 16, bearing the official party of 145. On the evening of July 18, the third night out, the officers and past presidents gave a reception; on the next evening Mr. W. R. Warner, a past-president of the society, gave an illustrated address on "What the Astronomers are Doing"; the evening of the 20th was given over to a musicale and on the following night Mr. John R. Freeman, a past-president, gave an illustrated address on "The Construction of the Panama Canal"; the two following evenings provided occasions for a dance and a conversazione. Deck games and other amusements relieved the few afternoons of any tendency to monotony and the ship's officers arranged daily inspection trips for those interested in the vessel. The party presented a silver cabinet to Captain A. E. Hambleton and a reading lamp to Chief Engineer C. C. Lapsley.

On the evening of July 25, the first day on British soil for the "Celtic" party, a complimentary dinner was given by Mr. John A. F. Aspinall, President of The Institution of Mechanical Engineers to several prominent American and British engineers attending the convention.

The first session of the joint meeting was opened by the Lord Mayor of Birmingham, Alderman W. H. Bowater, who welcomed both societies, reminding them of the fitness of selecting the engineering and manufacturing center of England for such a joint gathering. He further reminded the visitors that, if they did not find Birmingham a most beautiful city with a clean clear atmosphere, its condition must be taken as an indication of its industrial activity; the engineering profession he maintained caused more of the smoke than any other.

Mr. George Tangye, a member of the British reception committee and custodian of the James Watt relics, presented the American Society a framed letter written by Watt in 1797. Mr. Aspinall, President of The Institution, acknowledged the Lord Mayor's welcome for the British Society in a few words complimenting Birmingham on its part in the progress of engineering and industry; Dr. F. M. Goss, Vice-President of the American Society, also responded to the greetings of welcome and thanked Mr. Tangye for the Watt memento, which is to be displayed in a prominent place at the United Engineering Societies Building in New York City. Dr. Goss presided at all the following sessions, with Mr. Aspinall, in the absence of Mr. George Westinghouse, President of the American Society, and on account of the serious illness of Mr. Charles Whiting Baker, Vice-President.

Railway Engineering Papers.

Technical discussions were taken up on the first day after the exchange of compliments above noted. The first paper was on "English Running-Shed Practice" by Mr. Cecil W. Paget, General Superintendent of the Midland Ry., Derby. This contained a description of (1) equipment of locomotive houses and (2) features of management to secure as much work out of the engines as possible consistent with safety. The equipment for lifting one end for minor repairs, for washing boilers with hot water, for coaling, etc., in typical English sheds was described with a few remarks on cleaning reports, failure investigations, periodical examinations and overhaulings.

Mr. F. H. Clark, General Superintendent of Motive Power, Chicago, Burlington & Quincy R. R., Chicago, gave an abstract of four papers of similar interest; (1) "Handling Locomotives at Terminals" by Mr. F. M. Whyte, New York Cen-

tral Lines, New York City, (2) "Engine-House Practice," by Mr. F. H. Clark, (3) "American Locomotive Terminals" by Mr. W. Forsyth, "Railroad Age Gazette," Chicago, and (4) "Handling Engines" by Mr. H. H. Vaughn, Canadian Pacific Ry., Montreal.

The first named paper treated very generally of some features contributing to quick exchange of engines for through trains and outlines the duties of such officials as master mechanics, traveling foremen, engine-house foremen, yard foremen, shop foremen, etc., to show the division of responsibility, between the mechanical and transportation departments, as to design, construction maintenance, supply running and mechanical operation, on typical American railway divisions. The subject of locomotive pooling (placing any crew on any available locomotive) to secure a maximum locomotive mileage was taken up by Mr. Whyte. The opinion was expressed that pooling could be arranged inside the different classes of service to yield the maximum desirable mileage and yet to allow the crews to earn maximum wages.

Mr. Vaughn's paper contains the differing conclusion that pooling of engines is undesirable, under any condition, for passenger service; where traffic conditions admit of greater mileage than a single crew can properly run, the desirable limit can be reached by assigning two crews to the engine or three crews to two certain engines. For freight service, on account of slow irregular schedules, long runs and varying demands for engines, pooling becomes advisable on divisions where as many as 60 engines are despatched per day although even there, when assigned crews can be maintained, the cost of repairs and fuel decreases and quality of service improves.

Mr. Clark, in his own paper, showed the features of engine-house design and equipment generally considered good practice in the United States. A typical layout was shown with a 40-stall circular shed, having a central turn table, two approaching tracks and one outgoing track. Nearby were shown the washout system, the machine shop and store house, water tower and cinder pit. The coaling station, a reinforced-concrete type, is placed between the two approach tracks of the shed.

The paper by Mr. Forsyth was largely on the organization of the engine terminal at the East Altoona freight classification yard of the Pennsylvania Railroad, through which some 63,000 cars are moved each month and from which terminal an average of 243 locomotives are despatched in 24 hours. Here the engines on arrival go to the inspection pits where five men are employed on each engine to reduce the time of examination to a minimum. After inspection the engineer is relieved of responsibility and care while the engine goes to the cinder pit, coal wharf, sand house and finally to the shed or main track for further service. The details of engine tracing, repairs, despatching and staff organization to make the engine passage smooth were given in general.

These five papers were discussed together and, as might have been expected, there was a free exchange of somewhat different views on a few points. For instance, the British engineers gave the impression of favoring locomotive sheds with parallel tracks, often dead ended. It was said that so long as the shedmen used a little common sense in placing the engines there was no trouble. There was general approval of urging the hot-water washing out of boilers to reduce the time usually required in cooling off and in reheating after washing and for using drop pits to remove wheels, etc., rather than to lift up one end of the whole locomotive.

During the first day's session, just before the reading of the railway papers, Mr. Aspinall proposed sending a message of greeting and regret to Mr. Westinghouse. Mr. Westinghouse cabled a reply of thanks and good wishes which was read at the opening of the second day's meeting.

At this session the group of papers presented were of particular interest to designers and manufacturers of machinery.

Machine Shop Practice.

The first paper in this group was "High-Speed Tools and Machines to Fit Them," by Mr. H. I. Brackenbury, of Newcastle-on-Tyne, and was a review of progress in cutting metals. As this paper is reprinted elsewhere in this issue it is sufficient to state here that the author showed the difficulty in formulating rules for use of the new tool steels and the need of specializing the operations of the several machines as for roughing and for finishing. The newer machines for using the high-speed steels, conspicuous for greater weight and power, were described by typical examples.

The discussion of this paper occupied most of the session, necessitating the curtailing of the discussion on other papers of the group. The discussion was opened by three prepared contributions from American engineers. The first of these was by Mr. John Calder, Remington Typewriter Works, New York, and bore the title "Rapid Production in Machine Work." Several American records for increase in machine output were cited, such as turning 10 to 14 pairs of locomotive driving wheels per day, three to five car axles for 10-in. journals, 16 to 25 pairs of 36-in. car wheels, etc. Typical American car-wheel, turret and general manufacturing lathes, milling machines, etc., were described to show how increased rigidity, quick change of feeds and speeds, etc., had been secured and how the time between successive cuts had been reduced. The use of grinders in place of cutting machines was illustrated from American practice.

Mr. L. D. Burlingame, of the Brown & Sharpe Manufacturing Co., Providence, R. I., presented a formal discussion entitled "Data on Manufacturing Methods with Machine Tools." He showed examples of the extensive sets of special tools required to manufacture a modern machine tool, like a universal milling machine, on a commercial basis. The contribution was accompanied by several lantern slides to illustrate his company's practice in securing rapid accurate work.

In "Development of High-Speed Drilling Machines," by Mr. L. P. Alvord, of the "American Machinist," New York, a few record performances were noted. Some of them were interpreted as showing that the power required to remove a pound of metal decreases slowly as the speed is advanced in comparison with the reduction to increasing the rate of feed.

Mr. J. H. Wicksteed, Past-President of the Institution, of Leeds, called attention to the neglect of the double-cutting principle in the design of planers. After sketching the advantages at some length he stated that the desirability of the features of quick return (single cutting) or of double cutting met at a certain point; machines 4 or 5 ft. wide and up to even 20 ft. long might perhaps advantageously retain the quick return, but machines 8 or 10 ft. wide and 30 to 40 ft. long should have a double-cutting tool box. Several speakers dwelt on other ways of securing economy in the shop and on details of various steels and tools in use.

Mr. F. W. Taylor, Past-President of the American Society, of Philadelphia, in his discussion developed the idea that the improved art of cutting metals and the use of machine tools were but minor elements of the greater problem of doubling the output of men and machines in order that the great labor and manufacturing problems might be solved. He believed the first duty of manufacturers and engineers lay in disclosing to the workmen the fallacy of their belief that it was to their interest to "go slow" rather than to work at maximum capacity. The second duty set forth was the deliberate scientific study of the men's motions to find in what way their activity might be increased or made more effective. He cited the work of Mr. F. B. Gilbreth, of New York, in improving the practice of bricklaying as the result of such study. By devising a small platform to hold the materials at the same height as the wall, stooping over for bricks and mortar were eliminated. Bricks were sorted at the unloading pile and placed, right side up for laying, on a little frame for the bricklayer's platform. Mortar was carefully tempered so that bricks could be pressed into place without tamping, and mortar box and brick [illegible] were so placed that the materials could be taken simultaneously. Motions of the bricklayer had been reduced from 18 to 5 and 2, according to the work, and on actual construction the rate of laying had been increased on difficult work from 120 bricks per hour per man to [illegible].

Two papers on gear teeth were presented at the close of the preceding discussion: (1) "Tooth Gearing," by Mr. J. D. Stevens, of Birmingham, and (2) "Interchangeable Involute Gearing," by Mr. Wilfred Lewis, Philadelphia, Chairman of the American Society Committee on Standards for Involute Gearing.

In the first of these papers, Mr. Stevens showed the present need of greater accuracy in forming gears than was needed, or possible, a dozen years back. He outlined the several ways of forming the teeth and the slight differences that result to prevent interchangeability of the gears cut by different processes. He described his own studies of these interferences by means of cardboard models worked under glass plates. He believed that a new form of tooth might be devised that would eliminate these barriers to interchangeability and he advised a stub form with a 20° pressure angle (angle between tangent to both pitch circles at point of tooth contact and a line normal to tooth curves at point of contact). He argued for this design that (1) it could be used from a rack down to a 12-tooth pinion and could be cut with either a single cutter or a generating machine; (2) it would give a stronger tooth than now generally used; (3) a large proportion of the face would do useful work, and (4) the objection to a lesser contact pressure and a greater bearing pressure, due to the larger pressure angle, would be negligible.

Mr. Lewis' paper was an argument for the use of a pressure angle of 22½° with an addendum of seven-eighths of the module (pitch diameter, in millimeters, divided by number of teeth). This he believed could be adopted without fear of reduced efficiency in power transmission and with ample arc of action for all combinations. True involute forms could be made on these constants without empirical modification and would give results comparable with the best now obtained. Mr. Lewis described a machine, for testing the friction losses in gearing teeth, devised for experiments under the direction of Prof. Gaetano Lanza at the Massachusetts Institute of Technology. In addition to his formal paper Mr. Lewis orally presented figures recently derived with this machine. The stub tooth with a 20° pressure angle and addendum of 0.28 pitch showed less than 1% friction loss; the Brown & Sharpe 14½° tooth with addendum of 0.32 pitch showed 1.3% friction; in general there was little or no effect from change of pressure angle and only slight increase for addendum change. The loss in teeth alone was much smaller than generally supposed and such tests should do much to remove the prejudice against teeth of 20° and 22½° obliquity and should allow elimination of all interference between the extremes of a 12-tooth pinion and a rack with a true involute form to which all present methods of gear cutting could be adapted.

The proposed changes were opposed by a few American and British engineers who felt that the practical advantages of the present 14½° tooth were greater than the theoretical gain through the changes. The increased machine-shop equipment due to the change would cause confusion, it was stated, and the new gears might prove unsatisfactory on account of increased backlash due to the increased pressure angle.

This discussion ended the Birmingham sessions and, in acknowledgment of the hospitality of the several Birmingham officials and manufacturing concerns, resolutions of thanks were passed. Additional resolutions were passed by the American Society acknowledging the hospitality of their British friends.

The professional meetings were resumed on July 28 at the rooms of the Institution of Civil

Engineers, Great George St., London. The visitors were welcomed by Mr. Alexander Siemens, Senior Vice-President, and after the usual exchange of compliments, the papers on electric traction were presented.

Electric Traction Papers.

The following five papers were read in abstract: (1) "Electrification of Suburban Railways," by Mr. F. W. Carter, of Rugby; (2) "The Cost of Electrically-Propelled Suburban Trains," by Mr. H. M. Hobart, of London; (3) "Economics of Railway Electrification," by Mr. W. B. Potter, of Schenectady (read by Mr. H. H. Barnes, Jr., of New York); (4) "The Electrification of Trunk Lines," by Mr. L. R. Pomeroy, of New York (presented by Mr. C. W. Rice, of New York); (5) "The Electrification of Railways," by Mr. George Westinghouse, of Pittsburg (read by Mr. C. F. Scott, of Pittsburg).

In the first-named paper Mr. Carter confined his discussion to suburban traffic as there appeared to him little chance of the conversion of main steam lines where there were long distances between stops. It has been found in England that "electrification" would restore to old suburban lines much of the traffic lost through the competition of trams and omnibuses, so that the problem confronting a company was whether the expected gain would justify the expense. Little had been found to be desired in freedom from breakdown—the delays from all causes for December, 1909, averaging some 33 seconds per day per train on the District Ry. (operated over foreign steam lines in part) and only 2½ seconds on the Underground Electric Ry. tubes. The total cost of maintenance and repairs on the latter were only 1.2 cts. per car mile. In typical suburban service, the greater part of the energy input was used in acceleration and losses due to acceleration were held to be of the same order of magnitude for direct-current and single-phase systems. When heating of the motors determined suitability of equipment, the direct-current system was better than the single-phase for which forced ventilation had to be employed.

Mr. Hobart's paper was an open argument for the direct-current system of electric traction, although making general cost comparisons with steam operation. The chief items of cost different from those of steam operation, and differing for the two electrical systems compared, were taken as (1) cost of electricity, (2) charges on rolling stock, (3) cost of distributing system. The last item was assumed the same for both systems under the conditions of the roads for which estimates were made. Taking representative costs of electricity, at the car, at 1.74 cts. per KW.-hr. for direct current and 1.4 cts. per KW.-hr. for single-phase current, the total consumption per recorded train mile (180-ft. train), with a service of 22 mi. per hr. and one stop per 0.88 mile, amounted to 20 cts. for both systems. For a service of 30 mi. per hr. and one stop per 1.32 mile the cost for the single-phase system rose to 30 cts. and to 26 cts. for the direct current. The annual charges for rolling stock were placed at 17.2 to 21 cts. per train mile for the single-phase equipment and 12 cts. for the direct-current. The sum of the two items was stated to be some 6 cts. higher per train mile for moderate service and 12 cts. higher for severe service in the case of single-phase roads than for direct-current. Assuming $1 per train mile as gross receipts the single-phase system was estimated to absorb from 6 to 12% more of the gross receipts than the direct-current, depending on the severity of service. The paper dealt with suburban traffic only.

Mr. Westinghouse intended his paper to be a plea for the complete standardization of equipment for electrification of steam railways, but his leaning toward the single-phase system could not be absolutely eliminated. For the most part, such prejudice has been relegated to the five appendices to the main paper: (1) "The Single-Phase system of the New Haven Road," (2) "Data on Electric Locomotives of American Design," (3) "Comparisons of Systems," (4) "Electrified Steam Roads and Electric Roads for Trunk Line Service," (5) "Early History of Single-Phase Railway Motors." Mr. Westinghouse, in the main part of his paper, reviewed the equipment and running characteristics of the several direct-current, single-phase and three-phase systems in commercial use. He discussed the general requirements of an ideal standard system for interchangeable rolling stock and made a plea for that cooperation of all which alone could evolve such a system at this early date. (Mr. Westinghouse's paper was abstracted in Eng. News, July 7, 1910.)

Mr. Potter's statements on the same topic were radically different. He did not believe, for instance, that it was desirable to have the character of the energy supplied to the contact system uniform on account of the great difference in the requirements of specific cases of suburban and trunk-line service. But Mr. Potter discusses standardization only incidentally, for he considers, as the "economics," those peculiar conditions which make one development or another advisable. There is, however, from the first a leaning toward the direct-current systems and finally the paper slips into a commercial argument for the 1,200-volt direct-current system on interurban traffic. (Editorial comment on the papers of both Mr. Westinghouse and Mr. Potter, including a quotation from the latter, appeared in our issue of July 7, 1910.)

Mr. Pomeroy's paper gathered together a variety of comparisons of steam and electric railroading, bearing more or less, on the general proposition that no case could be made out for "electrification" unless an increase of net receipts could thereby be secured to more than pay interest on the extra capital needed. He reviewed some of the prevalent claims for relative cost of coal, savings through "electrification," advantages of electric locomotives, but also cited several statements to show when and how steam traction may still be more profitable than electric.

The discussion of these papers was full and vigorous, reminding the Americans of the discussions in their own country on the merits of direct-current and single-phase systems, which discussions had often been uncompromisingly protracted for hours. Mr. H. F. Parshall, of London, contrasted American practice, where the cost of transmission of current was the controlling factor, with practice in England, where the Board of Trade made such stringent regulations for most elaborate and complete transmission systems. After examination of the American lines, he was satisfied that the Board of Trade would never allow a New Haven system to be operated in England. He found American engineers generally of the opinion that for dense suburban travel, or where motor cars were applicable, the single-phase system was out of consideration.

Other speakers pointed out slight and permissible changes in Mr. Hobart's assumptions, that would change the values of his figures and place the direct-current and single-phase systems on nearly equal footings, so far as his estimates went. Other prominent persons even attacked Mr. Hobart's fundamental data. Mr. Hobart in turn criticised Mr. Potter's 1,200 volt line calculations, remarking that by following them through in his own way the single-phase system seemed preferable and the steam-operated line seemed preferable to both.

Mr. Aspinall, in closing the discussion and speaking as a railway manager, said that no railway manager could afford to close his mind to the advantages of whichever system would best increase the capacity of his line. If the 50% idle time of every locomotive, steam or electric, in awaiting service, could be eliminated there would be a greater saving than by any variations of specific system before noted.

At the close of the discussion the American society passed additional resolutions of thanks to the Institution, asking that they be made a part of the Institution's records.

Excursions, Etc.

On the afternoon of the first day, July 26, visits were made by various parties to works of interest in and about Birmingham, such as the Dudley Port testing station of the Pump & Power Co. (where was seen the Humphrey type of direct-acting explosion pump with a water piston, described in Eng. News, Dec. 2, 1909), the Frankley filter beds of the Corporation Water Works, the Austin Motor Co., the Metropolitan Railway Carriage and Wagon Co. Pleasure excursions were also made to Stratford-on-Avon, Worcester, Kenilworth and Stonleigh Park. On the evening of this day a garden fete was given in the Botanical Gardens, at Edgbaston, by the Birmingham reception committee. The gardens were beautifully illuminated and there was an exhibition of fireworks.

At the close of the second day's professional technical session, the last meeting held in Birmingham, the members and guests lunched in the town hall. Two alternative trips were planned for the afternoon—one to the new buildings of the University of Birmingham, opened in July, 1909, by the late King Edward VII., and the other to Messrs. Mitchell's & Butler's Brewery. The most of the members went to the University, where they were welcomed by the Principal, Sir Oliver Lodge. The visit to the University laboratories was of particular interest to many of the Americans, for the arrangements were worked out after a careful inspection of the best American schools.

As the closing event of the Birmingham visit, the Lord Mayor and the Lady Mayoress entertained the members and guests together with the City Council, city magistrates, and other officials at the Birmingham Council House, there being in all about 1,000 present.

The day following the Birmingham sessions was left open for the members to transfer to London. Excursions en route were planned, however, to Coventry, Rugby, Litchfield, Kenilworth, Warwick and Stratford-on-Avon for those who desired to visit important engineering works or places of historic interest. The main party left, early in the morning by special train, for Coventry where they visited the automobile works of the Daimler Motor Co., and the machine-tool plant of Messrs. Alfred Herbert. After these, the electrical manufacturing plant of the British Thomson-Houston Co., and the engine works of Messrs. Willans and Robinson at Rugby were inspected.

The London round of entertainment opened with a conversazione at the Institution House, St. James Park, given by the President and Council on the evening of July 18. After the session at the theatre of the Institution of Civil Engineers, July 29, the members attended garden parties given by Sir John and Lady Thornycroft and by Dr. and Mrs. W. H. Maw.

The annual dinner, which has always been a special attraction of the summer gatherings of the Institution, was turned into a banquet to the American visitors, and a notable company was assembled. Mr. Whitelaw Reid, the American Ambassador, in responding to the toast "The President of the United States" recalled the contributions of mechanical engineers of both countries to modern civilization and pointed out the need of preserving this progress through encouraging a profound respect for such authority as the toast implied, which meant ultimately obedience to law, protection of life, individual liberty and individual property.

On Saturday, July 30, were excursions to Marlow and Windsor, where luncheon and tea were served. Prominent town officials and members of the Institution acted as guides about these towns. Although there was a final dinner to the Council and past presidents of the American Society given by Sir William White (Past President of the Institution and Honorary Member of the American Society) and Lady White, these excursions really closed the program of the joint meeting—a meeting which all agreed had been of great service in helping each national group to understand the viewpoint of the other in the attack of a few of the greater problems before mechanical engineers everywhere.

The editors acknowledge their indebtedness, in preparing the above report, to Mr. Calvin W. Rice, Secretary of the American Society of Me-

chanical Engineers, and to Dr. W. H. Maw, Editor of London "Engineering." After the serious illness of the Editor of Engineering News, attending this joint session, these gentlemen forwarded to this journal full notes of the entire proceedings. This courtesy on the part of Dr. Maw may be taken as one more evidence of the cordial treatment accorded to the members of the visiting society.

High-Speed Steel Tools and Machines to Fit Them.*

By H. I. BRACKENBURY,† M. Inst. M. E.

High-Speed Tool Steel in the Shop.

INTRODUCTION OF HIGH-SPEED TOOL STEEL.—Those engineers who saw, at the Paris Exhibition in 1900, a lathe running at a high speed with a tool with its point red hot removing a dark blue chip, felt that they were witnessing the beginning of a revolution in tool steel and in machines fitted for its use. This revolution has now taken place and we are slowly accommodating ourselves to the new regime, but many changes have had to be made, not only in the direction of making far stiffer and more powerful machines, but also in our views regarding the values of certain types of machines for producing certain classes of work and the grouping of machines.

The use of high-speed steel for tools has been gradually extended, the old temper steel having to retreat from one position to another. For some time high-speed steel was considered to be useful only for rough cutting with the tool of the usual lathe form. Then its use was extended to twist drills with wonderful result; again its use was considered problematical in capstan and turret lathes where high speeds with copious supplies of oil or lubricant were already in vogue, but now no maker of such machinery would advocate the use of anything but the best high-speed steel. Milling cutters of all descriptions are made of high-speed steel, and although the tool makers still advertise the alternative of temper steel, those who have had experience of the high-speed milling cutters would not think of ordering cutters of temper steel, unless the cutter was only required to accomplish a small amount of work, in which case it would be policy to run slower rates with a cheaper tool. Reamers, chisels for chipping hammers, rivet snaps for pneumatic and hydraulic riveting devices, have all been found to give the greatest satisfaction when made from high-speed steel. Examining such a list of uses, it becomes apparent that this steel has other properties besides that of retaining hardness at high temperatures.

USEFUL PROPERTIES OF HIGH-SPEED TOOL-STEEL.—The three properties of modern high-speed steel are: (1) The edge can be made very hard; (2) hardness retained up to a high temperature; (3) toughness. These properties are what make the steel so universally useful, but when high-speed steel was first introduced it had only the property of retaining its hardness up to a high temperature. Much has been written about high-speed tools, their composition, highest cutting speeds, power absorbed for various cuts, etc., by such competent authorities as Mr. F. W. Taylor, Dr. J. T. Nicolson, Mr. J. M. Gledhill and others, and it therefore seemed better here to treat rather of workshop conclusions than to examine further into matters which have been so ably dealt with by the above writers.

There are three classes of high-speed tool steel, which will be called in this paper: (Class A) For cutting mild and medium steel; (Class B) for cutting hard steel such as tires, etc.; (Class C) for cutting very hard steel and for use in cases where a sharp and lasting cutting edge is required; especially useful in cases where deep cuts with fine feeds are used.

POWER REQUIRED TO REMOVE MATERIAL.—More power is required to remove a thin wide chip than a chip of double the thickness and half the width, that is, to remove a chip 1 in. wide with a feed of 1/16-in. requires more power than to remove a chip ⅛-in. wide with a feed ⅛-in. This is less noticeable with tools with sharp edges. Tools with blunt cutting angles require more power than tools with sharp cutting angles to remove the same amount of material, the objection to sharp cutting angles being that the edge is apt to break.

The total power used for a given cut, including the power absorbed by friction in the machine, increases at a smaller ratio than the increase in cutting speed, in other words, less horse-power is used per pound of material removed at high speeds than is used at low speeds. This is only true up to a certain point.

DIFFICULTY IN CUTTING-SPEED RULES.—Figures of the speeds and feeds and depths of cuts which can be taken with lathe tools of high-speed steel under ideal conditions are interesting, and are very useful in showing in what direction we should modify our old methods and design new machines, and to what perfection we should strive; but the author does not think these figures are of much use as a guide to what is actually performed in the general run of workshops. There are so many variations in the actual conditions that, without a careful study of each class of case, it is difficult to say what is the best rate to cut at. Mr. Taylor, in his most valuable work "The Art of Cutting Metals."* gives twelve variable elements, but even this number does not cover the whole ground, and such questions occur as one man working several machines and several tools cutting simultaneously. Thus, on certain work where there is a large amount of repetition, it has been found possible to employ to advantage lathes with two saddles and three rests to turn work from 3 to 4 ft. long. As one man looks after two of these lathes he has to keep six tools at work on very hard steel. It is quite evident that under these circumstances it is important that the tools should not require changing often, as this would cause the lathe to be idle for a portion of the time, and too much of the workman's energy would be used up in changing the tools and setting in the cuts. One of the advantages of the use of high-speed steel in the above case, is that the tools will generally run for the day without requiring to be ground. This work could be done at higher cutting speeds using one tool and grinding more frequently; the result would be more effective to watch but less satisfactory to pay for.

CUTTING ANGLES.—Regarding the question of cutting angles, careful experiments have shown that the sharper the angle is the less the amount of power required to remove a given amount of material, the feed and depth of cut remaining constant. On the other hand, the sharper the angle is, the more likely is the cutting edge to crumble or break, and the smaller is the body of steel to conduct away the heat generated by cutting. In no well-regulated machine shop do the workmen grind the tools they use; grinding machines with trained operators are now almost universally employed for this purpose.

The importance of working to standard angles is obvious, and the fewer the standards the better, so long as the loss in cutting efficiency is not greater than the gain in grinding and forging tools to a small number of standards. The question of what standards are required, must depend on the variety of work and material and quality of machines in a shop. The author strongly deprecates becoming a slave to standards when many variables are involved, and feels that it should be the duty of a capable shop manager or foreman to experiment with tools of various cutting angles when he has a suitable run of work.

High-speed steel has improved in the past few years and will probably improve in the future, and with these improvements we find the cutting edge remains sharper for a longer time and the cutting angles may be made more acute. As an instance, when turning axles at the most convenient feed and speed and depth of cut, the belt failed to drive the lathe when using the standard round-nose tool. A tool was ground with a smaller radius on the nose, a straighter cutting edge, and a sharper angle; the belt was found to have sufficient power to drive the lathe with the full depth of cut when this tool was used, and the tool was adopted as the standard for this particular work. The reasons for the above are: (a) The cutting length of the tool was diminished, less power being required to take a thick narrow chip than a thin wide chip; (b) the sharper angle presents less resistance to the chip after it is sheared from the body of the material. Such a tool would not have been suitable for the general practice of the shop where heavy feeds are used.

HIGH-SPEED STEEL ON TURRET LATHES.—On turret lathes the highest class of high-speed steel is now largely used, and tools with a very sharp cutting-angle are employed. A test, carried out at the works of Messrs. Alfred Herbert, gave the following result in reducing a mild-steel bar from 1½ ins. to ¾-in diameter at one cut, with tool clearance angle 7°; side slope, 35°; cutting angle, 48°.

Tool.	R.p.m.	Cutting speed, ft. per min.	Feed per rev.	Feed per min.	Lbs. removed per min.
Carbon steel.....	149	58.5	0.0134	2.01	0.753
Class C, special high-speed steel.....	470	183	0.05	23.5	8.8125

TWIST-DRILLS.—Perhaps the most striking instance of the value of high-speed steel is given by the use of twist-drills. The improvement obtained by the use of this steel for drills is more easily grasped than in the case of turning tools, as there are far fewer variables. Given sufficient power, a high-speed drill does three times the amount of work and requires grinding less frequently than the temper-steel drills. The author is not one to advocate the policy of scrapping all old material, but in the case of twist-drills, where any quantity of work is required to be done on steel, he advises the use of nothing but high-speed steel drills. One instance is given here, namely, a drill ¾-in. diameter passing through a cast-iron block 2½ ins. thick 8 secs. which is equal to a travel of 18¾ ins. a min.

FULL ADVANTAGE NOT TAKEN.—Although considerable use is made of high-speed steel in engineer workshops, the author ventures to say that, genera full advantage is not taken of its cutting powers. C tainly speeds have been greatly increased, but they h not been increased in the proportion warranted. doubt valuable economy has been effected by the creased speeds, and the length of time tools run with the need of grinding. We should not content oursel with these results, but strive to use to the full powers which the steelmakers have put in our hand

The author thinks that, although the rapidity of p duction with high-speed tools has been well emphas during the last few years, insufficient attention has b given to the accompanying savings. Where full is made of modern machinery the production, in so as roughing-out goes, is three times what it was un old conditions. This means that only one-third t number of machines, one-third the amount of spa one-third the number of operators, one-third the amou of shafting and about one-half the amount of sup vision, are required to produce the same amount work. Further, although the power required to dr machines capable of making full use of high-speed st is very large, the power absorbed for each pound metal removed is less for high-speed than for lo speed machines.

MACHINES FOR ROUGHING.—There is, in the a thor's opinion, only one way in which the full savi may be made, and that is by setting aside certain m chines for roughing and roughing only. It is qu unnecessary to replace all or even many of the machines, which have quite enough power to carry th finishing cuts at good speeds, nor is it desirable to u either the same class of machinery or labor for roug ing out as for finishing.

OLD MACHINES FOR HIGH SPEED.—There are a number of workshops where there is not the inclina tion or, owing to trade depression, the capital to buy many new machines. In such cases much may be done by making a judicious selection of the heaviest of the existing machines and increasing their belt speed, so that high speeds may be run with the back gear in. In some instances, the cones have been removed and replaced by wide pulleys, speed changes being provided for by means of sliding gears. Fortunately the English machine-builders of the past did not hesitate to put plenty of weight into their machines, so that, by increasing the driving power, excellent results may be obtained, but it is generally necessary to fit new gears.

Machines Fit for High-Speed Steel.

MAXIMUM POWER DEPENDS ON STIFFNESS OF WORK.—An idea what saving in cutting-time has been made by the use of high-speed steel can be gathered by a comparison of the power allowed for machines designed before and after its introduction. Engineers have also grasped the fact that the power which may be usefully employed depends upon the stiffness of the work and not on the height of centers in the case of lathes or the length of stroke, etc., in the case of other machines. Thus we find instances of 12-in. center lathes designed to use 50 HP., which is about ten times as much power as was allowed for in any of the pre-high-speed lathes. This increase in power must be accounted for by a desire for increased depths of cut and feeds as well as increased speeds. There is no doubt that the interest awakened by the introduction of high-speed tool steel has called so much attention to the subject of roughing out work that many improvements have lately been made which might have been made in earlier times. The author well remembers cases where recourse was had to putting three belts, one on the top of the other, to increase the very limited belt-power of some lathes.

Following are some examples of increases in horse-power provided:

	Increased from HP.
Turret lathe for 2¼-in. bars.....	2 to 10
Lathe, 6-in. center bars.....	1 to 4
Lathe, 10-in. center bars.....	2½ to 10
Lathe, 14-in. center bars.....	5 to 20
Lathe, 36-in. center bars.....	20 to 60
Lathe, 60-in. center bars.....	30 to 100
Slotting-machine, 12-in. stroke.....	9 to 15

LIMIT OF POWER APPLIED.—There seems to be no finality as to the amount of power which can be applied to a machine. We find a milling-machine described as capable of removing 1,400 lbs. of steel per hour which would entail a consumption of not less than 92 HP. Such a machine may be economical when it can be employed on a continual run of work requiring such cuts, but would be a serious charge when employed on lighter cuts. In the desire for rapid production from machines we must be careful not to overlook the consideration of the cost of power and value of material cut to waste in cases where the work could be made nearer to the size in a more economical way. The fact that by the use of high-speed machines a ton of cuttings can be made at a labor cost of 16 cts., must

*From a paper before the Institution of Mechanical Engineers, Birmingham, England, July, 1910.

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*[See Engineering News, Feb. 21, 1907.—Ed.]

make us forget that someone has to pay for a ton material and 15 or 16 cts. for power.

LIMIT OF WEIGHT AND POWER.—It is impossible lay down any law regarding the limiting point of the ight and power of machines, as the number of varia- es which enter into consideration is so numerous. here are, however, three principal governing factors, amely: (1) The length of time the machine will be sed for heavy cutting; (2) the length of time the ma- hine will be used for light cutting, (3) the length of me the machine will be at rest.

During (1) the machine is used efficiently; during (2) more is being paid for power and capital charges than f a lighter machine were used; during (3) more is aid for charges than in the case of a lighter machine. These considerations evidently point to the importance of using heavy machines for roughing only, but there are many cases where this cannot be done. Take, for nstance, the case of a drilling-machine which is gen- rally employed to drill and ream holes of an inch in diameter, but occasionally has to drill holes 3 ins. in diameter. In such a case it would be a mistake to install a machine capable of drilling the 3-in. holes at a quick rate, as the proportion of standing to working time is very large for a drilling-machine, and the time during which the machine would be employed at its full power would be very small. Some attempt has been made by means of the curves (see Fig. 4) to show the tendencies of these various factors, but of course each case must be taken on its own merits.

OBJECTIONS TO STEPPED CONE.—The stepped cone is rapidly becoming obsolete, except in the case of small machines. The obvious disadvantages of this method of changing speed are the trouble, and, in the case of boys, the danger of throwing a heavy high-speed belt from one step to another and the variation in power available from the different belt speeds.

Speed changes are provided for by means of sliding gears in the case of medium-sized machines and variable-speed motors in the case of larger machines. Such motors, worked on direct-current three-wire system, give a large range of speed which is excellent, but it is well to notice that at certain speeds with light cuts the efficiency of motor and machine may be far from good. It will be noticed that there is a drop in efficiency at the change from the low voltage to high voltage, and an extraordinary gain in efficiency when a change is made from the high voltage and high gear ratio to the low voltage and low gear ratio, the result being that practically the same amount of power has to be paid for at different cutting speeds.

It appears from the above that heavy lathes which are required to do both light and heavy turning should have the gear ratio arranged so that the full range of speed may be obtained from either voltage, and that builders of such heavy machines should give the total efficiency of the lathe and motor at various speeds and loads. No engineer would purchase a power-generating plant without obtaining a guarantee of its efficiency at various loads, and there seems to be no reason why less care should be given to the efficiency of plant using the power. It is true that the expenditure on power is in most cases only a small portion of the total expenditure, but when the total expenditure is large, the small portion becomes quite large enough to trouble about.

HELICAL GEARS.—The gears which are always in mesh should have helical teeth to ensure quiet and smooth running and to prevent chatter. The pinions should be hardened and, of course, all wheels should be made either of forged steel or steel castings.

It is of great importance to cut the teeth of gear-wheels to a considerable degree of accuracy.

Worm and worm-wheels should never be used unless hardened. The author has seen the teeth of a cast-iron worm-wheel 7 ft. in diameter almost entirely worn away in a few days; the introduction of high-speed steel has meant the replacing of many worm and worm-wheel drives by spur-gear drives. All feed arrangements must be amply strong, as in certain cases the side pressure is equal to the vertical pressure on the tool.

SPECIAL LATHES FOR ROUGHING.—Very powerful machines are now built for taking heavy cuts. The beds are made very wide to give ample support and bearing surface for the saddle, and the spindles are made of what appears to be excessive strength, but it is most important to have ample bearing surface and an absolutely rigid spindle to prevent chatter. A general rule is to make the diameter of the front bearing half the height of the center. Thus a 6-in. center lathe would have a 3-in. front bearing; one with a 12-in. center would have a 6-in.; and one with a 14-in. center, a 7-in. bearing.

There should always be a hole through the spindle, as this is required for the bolt for drawing up expanding chucks or for supporting the end of a boring bar. The tailstocks should be very massive and clamped to the bed by two bolts in the case of the smaller sizes, and three bolts for larger sizes; the diameter of the barrel should be one-third the height of centers.

One maker of lathes provides an arrangement of expanding cones with a belt driving by its bevelled edges, and by this means any speed between the highest and lowest can be obtained. When applied to a cutting-off machine, arrangements are made so that the speed automatically increases as the diameter being cut diminishes.

TURRET LATHES.—Turret lathes have been greatly strengthened, and one capable of dealing with bar up to 2¼ ins. in diameter can reduce a bar from 2¼ ins. to 1 in. diameter at a traverse of 11⅝ ins. per min. with an expenditure of 20.7 HP., when using the latest form of high-speed tool steel (Class C). The ordinary steadies were found quite useless at this high duty, and a roller steady has been introduced with excellent results. Such a machine fitted with a roller steady averages an output at least 33% greater than the output of the older machines designed for the use of ordinary high-speed steel, and at least 100% more than the pre-high-speed tool machines, so that the extra cost of the modern machines is small compared to the saving. Of course, such cuts as given above are not often required, so that a provision of 10 HP. is quite sufficient for all ordinary purposes. Taking the production from one of these machines built in 1900 as the unit, the following figures are obtained:

1900 machine, cost per unit of production.....	$543.20
1905 machine, cost per unit of production.....	402.24
1910 machine, cost per unit of production.....	344.08

These figures would vary with the class of work; on some work the gain would be more, on other work less. This case has been fully dealt with here, as some doubt has been expressed as to the advantage of the use of high-speed tools in turret lathes.

MILLING MACHINES.—The power allowed for milling machines has been greatly increased within the last few years, but it is very doubtful if milling machines should be used, except in special cases, for heavy roughing work, as the power required to remove material with a milling cutter is very large as compared to tools of the lathe type. The milling cutter may be compared to a lathe-tool with a very long cutting-edge removing a thin wide chip. The actual consumption of power to remove a pound of material with a milling cutter is about double that required by a lathe-tool.

PLANING MACHINES.—A great advance has been made in the cutting speed of planing machines, and naturally with the increase in cutting speed came a desire for a quicker return-stroke. Heavy planing machines now have a return-stroke speed of 90 ft. per min. and lighter machines are made with a return stroke up to 180 ft. a min., the shock at the reverse being absorbed by recoil springs. Various devices are now made which can be fitted to pre-high-speed planing machines by means of which the above results may be obtained at a moderate expenditure of money, and the results are most satisfactory. It seems a pity that more use has not been made of the arrangement fitted to the planing machines designed by Sir Joseph Whitworth for cutting on both strokes; certainly for roughing out this is very economical.

A RAILWAY ACCIDENT IN FRANCE on Aug. 14 is reported to have killed 37 persons and injured 58 others. An excursion train collided at high speed with a freight near Saujon. Six cars of the excursion train were telescoped. The accident is ascribed to a misplaced switch.

AN EXPLOSION OF SAWDUST, Aug. 6, wrecked the power-house of the Diamond Match Co., at Barber, Cal. Three of the walls were demolished and the roof blown off. The debris was further damaged by fire. Two employees were fatally hurt and several others suffered severe injuries.

A LUMBER-YARD FIRE IN BOSTON Aug. 9 destroyed the buildings of the Blacker & Shepard Co., and 10,000,000 ft. of lumber piled in their yards at the corner of Dover and Albany Sts. Five brick buildings on the west side of Albany St. were also destroyed. The loss is estimated at about $1,000,000.

GREAT FLOODS IN JAPAN during the first half of August inundated several districts. In Tokio two of the principal wards were almost entirely submerged and nearly 4,000 houses were washed away. Thousands of persons were made dependent upon public relief and 1,112 are reported dead or missing.

A FIRE AT THE BRUSSELS EXPOSITION on Aug. 14 destroyed the entire British and Belgian sections, a part of the French section and the Kermesse, the exposition's "Coney Island." Two persons were killed and 30 injured. The loss of life was remarkably low when it is considered that about 100,000 persons were in the Kermesse alone. The loss is estimated to exceed $6,000,000. The exposition grounds were closed Aug. 15 to facilitate the work of clearing away the ruins of the burned sections, but will be reopened, it is expected in a few days.

A RETAINING WALL ACCIDENT at Massena, N. Y., on Aug. 15, in which two men were killed, was exaggerated by press reports into a large dam failure. The facts in the case are stated by Mr. J. W. Rickey, M. Am. Soc. C. E., of the St. Lawrence River Power Co., as follows:

We are constructing a concrete forebay dam adjoining the Massena power-house. At the east end of the dam a railroad bay is constructed so that railroad cars can be shifted onto the dam. The tracks in this bay are supported by concrete walls, these walls being arched to form buttresses to the dam. The pockets in this wall, between the buttresses, were being backfilled with earth, and excavation was being carried on adjacent to the wall for the purpose of continuing the construction. The lateral pressure of the earth overturned the wall, with the fatalities above noted. No serious damage resulted, as only about 300 cu. yds. of concrete will have to be replaced. This will not delay the completion of the work. No property was jeopardized and no construction plant was wrecked.

AN ALTITUDE OF 6,750 FT. above ground is reported to have been reached by J. A. Drexel at Lanark, Scotland, with a Wright type of biplane on Aug. 12. The altitude was determined by barograph readings which have not been reported in corrected figures.

A 485-mile cross-country flight was started from Paris, France, on Aug. 8, under the patronage of "Le Matin." The course lay through Troyes, Nancy, Mezieres, Charleville, Douai and Amiens. Eight contestants started on the first leg, but this number soon fell to two. The race was completed Aug. 16, one Le Blanc winning on a Bleriot monoplane.

In making a double parachute drop from a hot-air balloon at Asbury Park, on Aug. 12, one Benjamin Prinz, slipped from the bar of his second parachute at a height of 1,000 ft. and fell to his death.

THE SCHLESINGER ELECTRIC RAILWAY PATENT, which was applied for in 1885, when electric railways were in their infancy, and which is said to affect nearly all electric railways in this country, has been in litigation for several years both as to its validity and its ownership. A decision rendered by Judge Bradford in the U. S. Circuit Court (Pennsylvania) on July 28, 1910, covers the following points: (1) Wm. M. Schlesinger was the original inventor, (2) the Allis-Chalmers Co. is the owner of the patent, (3) the General Electric Co. and the Hestonville, Mantua & Fairmount Passenger Ry. Co. have infringed upon the first claim of the patent, and (4) that profits derived by the infringing companies since Dec. 15, 1896, may be recovered by the owning company. The application for this patent was filed on Nov. 24, 1885, and the patent (No. 546,059) was issued Sept. 10, 1895. The first claim, which was the basis of the suit, covers an electric railway system in which the working conductor (trolley wire or third rail) is divided into insulated or disconnected sections, each section being connected to the generator or bus-bar at the power station through a separate feeder provided with an automatic circuit breaker or other protective device. The ownership of the patent by the Allis-Chalmers Co. has been upheld by a previous decision of the U. S. Circuit Court of Appeals. In the present suit, an injunction has been issued against the use of and manufacture or sale of the infringing apparatus by the defendant companies, and we are informed that after hearing arguments the court refused to suspend this injunction pending appeal.

THE RECONSTRUCTION OF THE PUBLIC WORKS of Messina, Sicily, is the subject of a proposal made to the Italian Government by an English syndicate. This city, it will be remembered, was destroyed by an earthquake in 1908. The syndicate offers to build a breakwater, pier, military barracks, university, city hall and other public buildings and sewerage system within five years' time. It is reported that the banking firm of Stimons & Co., of London, is willing to advance the Italian Government $115,000,000 at 3% interest to carry on the work. According to a statement by U. S. Consul Arthur Garrels, of Catania, the whole matter is yet in a very tentative form, not having been made the subject of definite resolution before the Italian Chamber of Deputies. Mr. Garrels states that the English syndicate mentioned is headed by Mr. Sinclair Poley, proprietor of the "London Daily Mail."

DREDGE MINING IN VICTORIA, AUSTRALIA.—In the annual report of Mr. D. B. Sellars, Engineer in charge of dredge mining and hydraulic sluicing, is a summary of operations which shows that in 111 dredging plants, 19,971,131 cu. yds. of material were turned during 1909, with a return of 88,339 ozs. of gold valued at $1,714,000. This is an average of 2.1 grains of gold per cubic yard of spoil. In addition to the gold, 33.75 tons of tin were recovered, having a value of $13,000. The area worked over was 737.75 acres, showing an annual yield of 120 oz. of gold per acre. There were 1,867 employees. The dividends amounted to $256,000, a decrease of $53,300, or 17% from the previous year. The total gold yield showed a decrease of 15,828 oz., or 15.2%. Including the returns from ten hydraulic sluicing plants, the total spoil moved in 1909 was 20,703,092 cu. yds., from which 88,969 oz. of gold, and 70.3 tons of tin were recovered. The yield per acre remains the same. In ten years these

operations have caused the handling of 129,204,126 cu. yds. of spoil from which the average yield was 2.1 grains per cu. yd. or 142.4 oz. per acre. In this state "dredge mining" is a term applied to processes whereby alluviums are broken down in large quantities and elevated, passed or conveyed with water through sluices for recovering gold and tin. The term includes bucket dredging and hydraulic sluicing by centrifugal pumps and jet elevators.

ALASKAN MINING IN 1909.—The U. S. Geological Survey has published in Bulletin 442 an advance chapter of the report on the mineral resources of Alaska. From this it appears that the production of gold was worth $20,463,000, an increase of 6% over 1908 and the largest since the banner year of 1906. This production was divided between placers, $16,322,000, and lodes, including return from copper ores, $4,107,363. The Yukon placers showed for 1909 their greatest production. Dry weather curtailed the output from Seward Peninsula. The discovery of placers in the Tunoko Valley, it is stated, promises to be important.

Since 1880 Alaska has produced $162,686,455 worth of gold of which $118,219,757 came from placers. There was a decrease in copper produced in 1909 from a value of $605,267 to $536,211. The Bulletin contains a strong plea for easier laws in regard to Alaskan coal lands. It is maintained that present delay in issuing patents and clamor against claimants has discouraged claimants and investors, and generally hampered all development.

ROAD TREATMENT WITH WASTE SULPHITE liquors was experimented with by the U. S. Office of Public Roads in 1909. The methods and some idea of the results obtained are given in Circular No 92 of that office, which also reviews experiments with various other road-treating materials. Waste sulphite liquor it may be explained, is a by-product liquid or waste from the manufacture of wood-pulp by the sulphite process. Both crude and concentrated material was tried. The concentrated waste sulphite liquor is described in the bulletin as

"a dense, sticky liquid, miscible with water, and having a specific gravity of from 1.267 to 1.270 at 25°C. Its binding value is dependent upon the presence of so-called calcium-magnesium-ligno-sulphonate, which is produced in the manufacture of wood-pulp according to the sulphite process.

On a piece of road in the Agricultural Department grounds, Washington, D. C., built of trap rock with a soft limestone binder, there was applied equal parts of waste sulphite and water. The roadway was sprinkled three times with the mixture at the rate of .54-gal. per sq. yd., or .27-gal. per sq. yd. of the original material. This was on March 17. Until about May 15 "the dust was successfully laid and the road surface well bound." Between then and June 1, "the road showed signs of becoming dusty and was watered for a number of times." On June 1, a portion of the road was again treated with the same material, but in a 20% dilution, giving .073-gal. of the original material per sq. yd. The total cost of this experimental treatment, figuring the waste sulphite at 12 cts. per gal. delivered, is given in the circular as follows:

Two laborers for bailing liquor, ⅝-day, at $2....	$1.50
One sprinkling cart, ⅝-day, at $5.....	1.88
total	$3.38
Cost of labor per square yard (1,093 sq. yds., total), first application.....	$0.0031
Approximate cost of material per square yard, first application	.0324
Total	$0.0355
Two laborers for bailing liquor, 1/16-day, at $2..	$0.25
One sprinkling cart, 3/16-day, at $5.....	.94
Total	$1.19
Cost of labor per square yard, second application..	$0.0011
Approximate cost of material per square yard..	.0088
Total	$0.0099
Total cost per square yard.....	$0.0454

After describing other experiments with the same material, some of it in the crude instead of in the concentrated form, the following conclusions were given:

From these experiments it would seem that crude waste sulphite liquor in single applications has but little value for road treatment, but that the concentrated material may be classed as a temporary or semipermanent dust preventative and road binder. It is possible, however, that, if crude liquor were applied daily as in ordinary water sprinkling, its use would prove economical in localities where it is produced, and that the base would concentrate in the road and eventually become a valuable binder.

USING ODD LENGTHS OF LUMBER is gaining in favor both in theory and practice, according to U. S. Forest Circular No. 180. A resolution in favor of getting away from the practice of sawing lumber in even lengths only was adopted by the National Lumber Manufacturers' Association in 1909. Investigations made on the Pacific Coast and in the South by the U. S. Forest Service show that the use of odd lengths will increase the output of the various classes of lumber by 2%, and that the saving will come from material heretofore wasted. The bulletin states:

For the manufacturer there is a salvage of waste material which will pay for itself and bring in a profit besides. For the builder there is a present need of odd lengths which is not now supplied. For the most economical results he needs nearly 40% of odd-length stuff. There is no prospect of his getting more than 16%. He will not be oversupplied. Conditions, therefore, emphasize the advisability of manufacturing odd lengths. It remains for manufacturers, retailers, and consumers of yellow pine to get together and agree upon means of bringing them into use under the most favorable conditions for the trade.

THE POWER CONSUMED IN TURNING STEEL CAR-wheel tires was measured in tests made in three railway repair shops in Germany, as reported by B. Schwarze in "Organ für die Fortschritte des Eisenbahnwesens," July 15, 1910. The figures obtained vary from 0.106 to 0.204 KW.-hrs. per kilogram metal removed, or 0.065 to 0.124 HP.-hrs. per lb. It appeared that new tires required a greater energy-consumption per pound than worn tires. This work was done at rates of 1.24 to 3.3 lbs. steel per minute. The average power consumption was 4.2 to 10.2 KW.; the maximum momentary draft was 9.5 to 24.5 KW.

Personals.

Mr. H. A. Sumner, M. Am. Soc. C. E., of Denver, Colo., has resigned his position as Chief Engineer of the Denver, Northwestern & Pacific Ry.

Mr. I. Paul Jones, Jun. Am. Soc. C. E., has resigned his position with the U. S. Reclamation Service, at North Yakima, Wash., to enter the service of the Sacramento Valley Irrigation Co., at Willows, Cal.

Mr. Fairfax Harrison, a Vice-President of the Southern Ry., has been elected President of the Chicago, Indianapolis & Louisville Ry. to succeed Ira G. Rawn whose death was noted in Eng. News, July 28, 1910.

Mr. F. Lavis, M. Am. Soc. C. E., has been made General Manager of the Dominion Construction Co., general railway contractors. He retains his interest in the firm of Guerber, Lavis & Co., 50 Church St., New York City, for which he will act henceforth in an advisory capacity.

Mr. L. N. Jackson has been appointed Engineer of Maintenance of Way of the Chesapeake & Ohio of Indiana Ry., succeeding Mr. G. S. Foster. This change is made in connection with the taking over of the Chicago, Cincinnati & Louisville R. R. by the Chesapeake & Ohio Ry.

Mr. Charles Whiting Baker, Editor of Engineering News, was taken seriously ill at the Queen's Hotel, Birmingham, England, just after his arrival on the 25th of July to take part in the joint meeting of the American Society of Mechanical Engineers, and the Institute of Mechanical Engineers of Great Britain. After the departure of the American Engineers for London, where they were to hold meetings the last of the week, Mr. Baker developed symptoms of scarlet fever; he was carried to the private hospital of Dr. Middleton, at Harborne, near Birmingham. His case is progressing favorably, but his return to New York will be delayed by the necessary isolation period until the last of September.

Obituary.

Wm. H. Silverthorn, President of the Railway Steel-Spring Co., of New York City, died Aug. 13 at his home in Painesville, Ohio, at the age of 60 years.

Charles Frederick Walker, at one time in charge of the Cleveland office of Engineering News, died at East Orange, N. J., on Sunday, Aug. 14. Mr. Walker left this journal to enter the ministry. At the time of his death he was serving as Rector of the Church of the Good Shepherd, Buffalo, N. Y.

Albert Spies, M. Am. Soc. M. E., President of the "Foundry News" Co., died Aug. 16 at his home in Jersey City, N. J., aged 48 years. Mr. Spies was born in New York City. He was graduated at Stevens Institute of Technology in the class of 1881. For some years he was an editor of "Cassier's Magazine."

Paul S. Prendergast, of St. Paul, Minn., a civil engineer in the service of the Great Northern Ry., died Aug. 9 at Great Falls, Mont., aged 32 years. He was a graduate of the University of Minnesota and had been in the employ of the Great Northern Ry. almost continuously since June, 1901, serving as a leveler, transitman, Assistant Engineer on Maintenance of Way and Construction, and Locating Engineer. At the time of his death, he was Engineer in charge of an important revision of line between Armington and Great Falls.

James E. Hurley, General Manager of the Atchison, Topeka & Santa Fe Ry., died Aug. 16 at Carlsbad, Austria, where he had gone for his health. Mr. Hurley was born at Wapello, Iowa, in 1860. He entered the service of the Santa Fe in 1880 as a brakeman. He became Assistant Superintendent of the Missouri division in 1891 and served during the next ten years as Assistant Superintendent and Superintendent of various divisions. In 1901 he was made Acting General Superintendent of lines west of Albuquerque, and later became General Superintendent successively of the western and eastern grand divisions. He had been General Manager since May, 1905.

Engineering Societies.

COMING MEETINGS.

LEAGUE OF AMERICAN MUNICIPALITIES.
Aug. 23-26. Annual convention at St. Paul, Minn. Secy., John MacVicar, Des Moines, Iowa.

LAKE SUPERIOR MINING INSTITUTE.
Aug. 24-26. Annual meeting at Ironwood, Mich., and Chicago, Ill. Secy., A. J. Yungbluth, Ishpeming, Mich.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Sept. 5-9. Annual meeting at Milwaukee, Wis. Secy., W. C. Woodward, Washington, D. C.

NATIONAL CONSERVATION CONGRESS.
Sept. 5-9. Second annual meeting at St. Paul, Minn. Secy., Thomas R. Shipp., St. Paul, Minn.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES.
Sept. 6-8. Annual meeting at Thousand Islands, N. Y. Asst. Secy., Walter Neumuller, 55 Duane St., New York City.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Sept. 6-9. Annual convention at Rochester, N. Y. Secy., Frank P. Foster, Corning, N. Y.

MICHIGAN GAS ASSOCIATION.
Sept. 8-12. Annual meeting on board steamer sailing from Detroit, Mich., Secy., Glenn R. Chamberlain, Grand Rapids Gas Light Co., Grand Rapids, Mich.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 13-16. Annual convention at St. Louis, Mo. Secy., A. P. Dane, Reading, Mass.

ROADMASTERS AND MAINTENANCE-OF-WAY ASSOCIATION.
Sept. 13-16. Annual convention at Chicago, Ill. Secy., Walter E. Emery, Chief Engineer, Peoria & Pekin Union Ry., Peoria, Ill.

COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION.
Sept. 21-23. Annual convention at Colorado Springs. Secy., J. C. Lawler, P. O. Box 938, Colorado Springs.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 21-23. Annual convention at Rochester, N. Y. Secy., Willard Kent, Narragansett Pier, R. I.

NATIONAL IRRIGATION CONGRESS.
Sept. 26-30. Annual meeting at Pueblo, Colo. Secy., Arthur Hooker, Pueblo, Colo.

AMERICAN STREET & INTERURBAN RAILWAY ASSOCIATION.
Oct. 10-14. Annual convention at Atlantic City, N. J. Secy., H. C. Donecker, 29 West 39th St., New York City.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 11-14. Annual convention at Erie, Pa. Secy., A. P. Folwell, 239 West 39th St., New York City.

RAILWAY SIGNAL ASSOCIATION.
Oct. 11-13. Annual meeting at Richmond, Va. Secy., C. C. Rosenberg, Bethlehem, Pa.

AMERICAN ELECTROCHEMICAL SOCIETY.
Oct. 13-15. Annual meeting at Chicago, Ill. Secy., Jos. W. Richards, Lehigh University, South Bethlehem, Pa.

NATIONAL ASSOCIATION OF CEMENT USERS.—The seventh annual convention of the Association will be held Dec. 12-23, 1910, in the Concert Hall of the Madison Square Garden, New York, N. Y. The seventh annual exhibition of the Association will be held combined with the first annual Cement Show of New York under the auspices of the Cement Products Exhibition Co., of Chicago, Ill.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS.—The annual summer meeting was held at Scotland and New London, Conn., on Aug. 16. The members and their guests first visited the dam and power station of the Uncas Power Co., at Scotland and then took a special electric car for New London, through the towns of Windham and Norwich. Dinner was served at Ocean Beach near New London, after which a short business meeting was held.

AMERICAN SOCIETY OF ENGINEER DRAFTSMEN.—On June 18 the first steps were taken in the formation of this society. The objects of the society are to be the advancement of engineering knowledge and practice and the maintenance of a high professional standing among its members. There will be meetings for the reading and discussion of professional papers and for social intercourse. The government of the society will be along the lines of similar engineering societies, the important features of the work being in charge of committees of members. The membership consists of Honorary Members, Members and Juniors. Full members must be 21 years of age or over, and must have such acquaintance with drafting as will give competency as a designer or in the preparation of drawings for actual construction. Juniors must have such knowledge as will fit them for subordinate positions in the drafting room and will lead to final qualification as a member. The officers of the new society are: President, E. F. Chandler; Vice-President, W. B. Harsel, and Secretary and Treasurer, Henry L. Sloan. The headquarters are at 116 Nassau St., New York City.